PROGRAM SYSTEM OPERATION

project
mercury

prepared for NASA

MC 109

project
mercury

PROGRAM SYSTEM OPERATION

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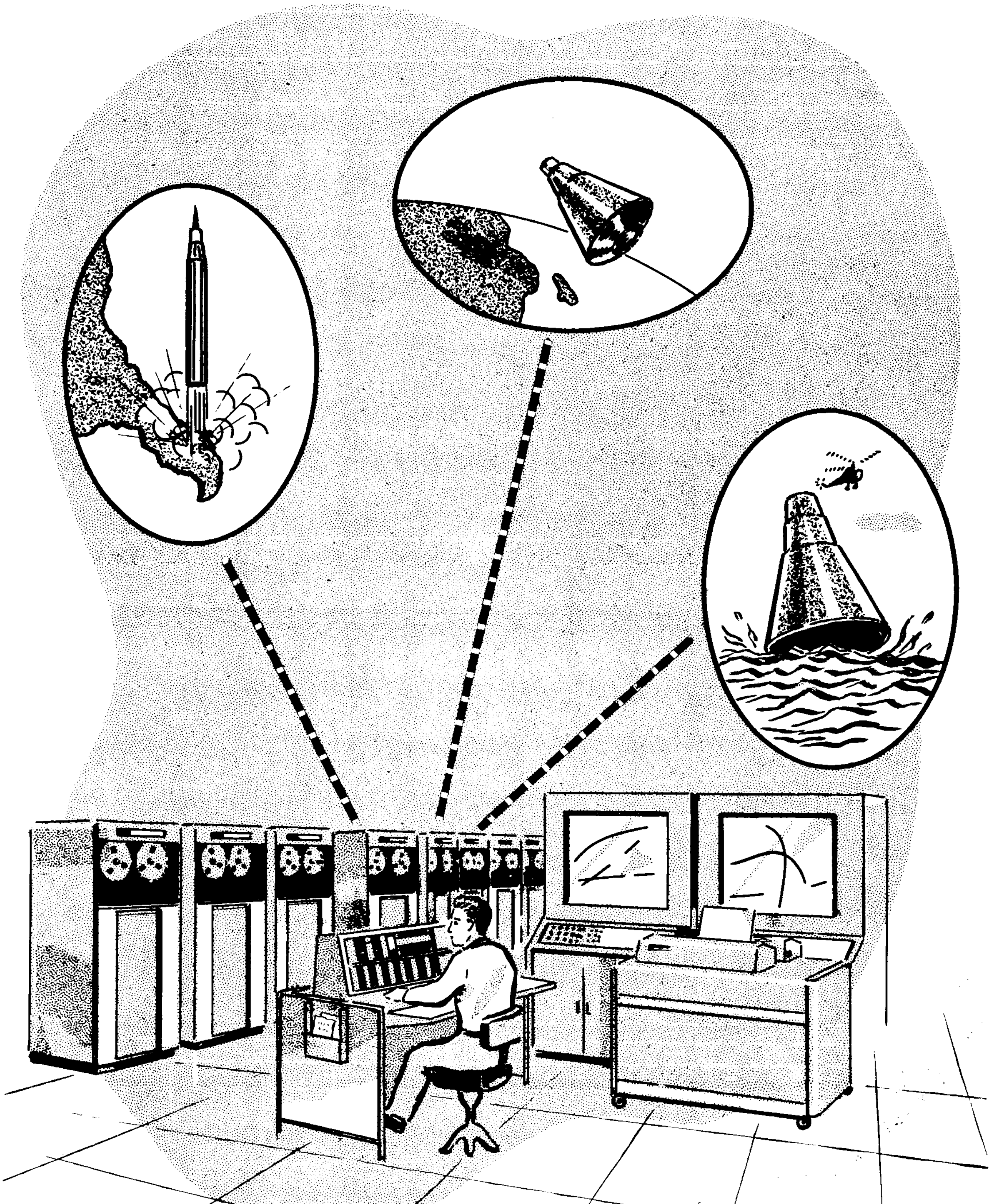

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Section 1

INTRODUCTION

The Mercury Program System as designed by IBM for the National Aeronautics and Space Administration has been documented in detail in manuals MC 101 through MC 110. This manual (MC 109) presents the methods of testing this program system thus proving its operational capability with the entire Mercury complex.

The program system is part of a much larger complex of equipment including communication channels and the Mercury Tracking and Ground Instrumentation System. The size and physical proximity of the Mercury system equipment proposes that program system testing be performed in the following three levels:

a) Simulated Tests— The Goddard Space Flight Center (GSFC) computers and the DCC clock are used in this test. The test uses locally produced simulated data. Simulated tests are supervised by Goddard.

b) Unsimulated Tests—These tests are divided in two areas, 1) local input which tests the entire Goddard complex using locally produced simulated data, and 2) remote input which tests the entire Mercury system using simulated data sent to Goddard by the tracking sites. These tests are also controlled by Goddard.

c) Network Drills— Here, as in the unsimulated tests, the entire Mercury system is tested. The differences being that the simulated data from the sites is transmitted according to a pre-arranged procedure and is monitored by the site director. The Network Drills are supervised by the Mercury Control Center.

Section 2, Program System Testing, describes the above three tests by which the Mercury Program System is prepared for mission operation. Also included in Section 2 are on-line message printouts representing the sequence of events for a typical mission and a discussion on the generation and usage of the system log tape which contains all inputs and outputs of the Goddard computers.

Section 3, Operating Procedures, outlines the operating procedures for the programming systems at Goddard and Bermuda. Pre-mission procedures at Goddard involve last-minute checks of the system and the actual loading of the program into the computers. During the mission, the Computer Operational Director and his staff constantly monitor computer operations and maintain contact with the Mercury Control Center. Following the mission, the Postflight Reporter program analyses the log tape data. The program decodes the data and collects and arranges it for a more complete analysis at Cape Canaveral and Langley Field.

Overall supervision of the Bermuda programming system is the responsibility of the Bermuda Operational Program Director, who manages all computing activities and participates directly in mission support operations. Pre-mission procedures are used for a last-minute checkout of the Bermuda system including the writing of both the Bermuda system tape and the Bermuda station characteristics tape. Final preparation activities prior to a mission are directed toward loading the program into the computer. During the mission, the Bermuda Operational Program Director monitors all operation, maintaining constant contact with the Flight Dynamics Officer and the Maintenance and Operations Chief at Bermuda. Post-mission procedures for Bermuda do not include participation in the Postflight Reporter program as is the case in Goddard postflight operations, however, the Bermuda log tape is saved and the high-speed input and output data is analysed.

Section 4, Mission Countdown, contains the mission countdown requirements for both Goddard and Bermuda. In addition to being the computation center of the worldwide Mercury complex, the Goddard Space Flight Center also serves as the communication center for all Mercury missions, and therefore its role in the countdown is quite complex. Goddard performs most of the countdown testing and analyses with the Mercury Control Center and Bermuda. Three hours before launch, the Mercury Program System is turned over to the National Aeronautics and Space Administration—Space Task Group (NASA/STG) Flight Dynamics Officer at Cape Canaveral for final checkout.

Countdown procedures for Bermuda are brief compared with those used at Goddard. Less equipment, fewer personnel, and less overall site participation is required since Bermuda's most important contribution to the mission occurs during early orbit. As at Goddard, the Bermuda Operational Programming Group is responsible for operating the Mercury Program System during a mission; other groups or persons provide communication support, equipment maintenance and testing, and control support for the operational program.

Section 2
PROGRAM SYSTEM TESTING

The Mercury Program System is part of the Mercury complex which includes the Mercury Tracking and Ground Instrumentation System. Sometime prior to a real-time Mercury mission, the program system in conjunction with the Goddard computing equipment and the entire Mercury complex must be tested in a manner that approximates the actual system operation during the mission.

Program system testing is the means of verifying that the computer program at Goddard has the ability to furnish in real time all specified output computations relating to all phases of a Mercury mission. Among the output requirements of the programming system are the display of such quantities as trajectory deviations from nominal, orbital capabilities, computed time of retrofire, computed impact point and other computed values contributing to a successful mission.

In a Mercury mission, the duplex IBM 7090 system at Goddard (see Figure 2–1) serves as the focal point of a large network of data links, each of which terminates at some distance from the computer. In most cases the termination of each data link is a Mercury tracking site. The tracking sites are strategically located around the world in such a manner that in a normal mission the capsule passes directly over or within communication range of each site. It is from these sites and through the data links that the computers receive inputs, processes this data, and displays the quantities at the Mercury Control Center.

Referring to Figures 2–2 through 2–4 one can see that to have the world wide Mercury complex operate as a single system, many tests are necessary to verify the operational capabilities of the various segments of this system.

To test the operation of the entire Mercury system, i.e., computers, program, data links, and data terminals for successful mission support, it is first necessary to test the computational center of the network—the Mercury Program System. Only after developing the operational readiness of the program system is an attempt made to check some of the data links with the program system.

Despite the fact that the system is being tested by levels, i.e., first the computer program alone, then with more and more of the network components added with each level, the computer program operation is the same as if the whole network is participating and a mission is in progress. To accomplish this, a unique system of simulation programs and techniques have been developed. As mentioned, these simulation tests begin with the Mercury Program System and the computers only and expands to include the entire world wide tracking network.

FIGURE 2-1. PARTIAL VIEW OF THE IBM 7090 COMPUTER FACILITY AT THE GODDARD SPACE FLIGHT CENTER

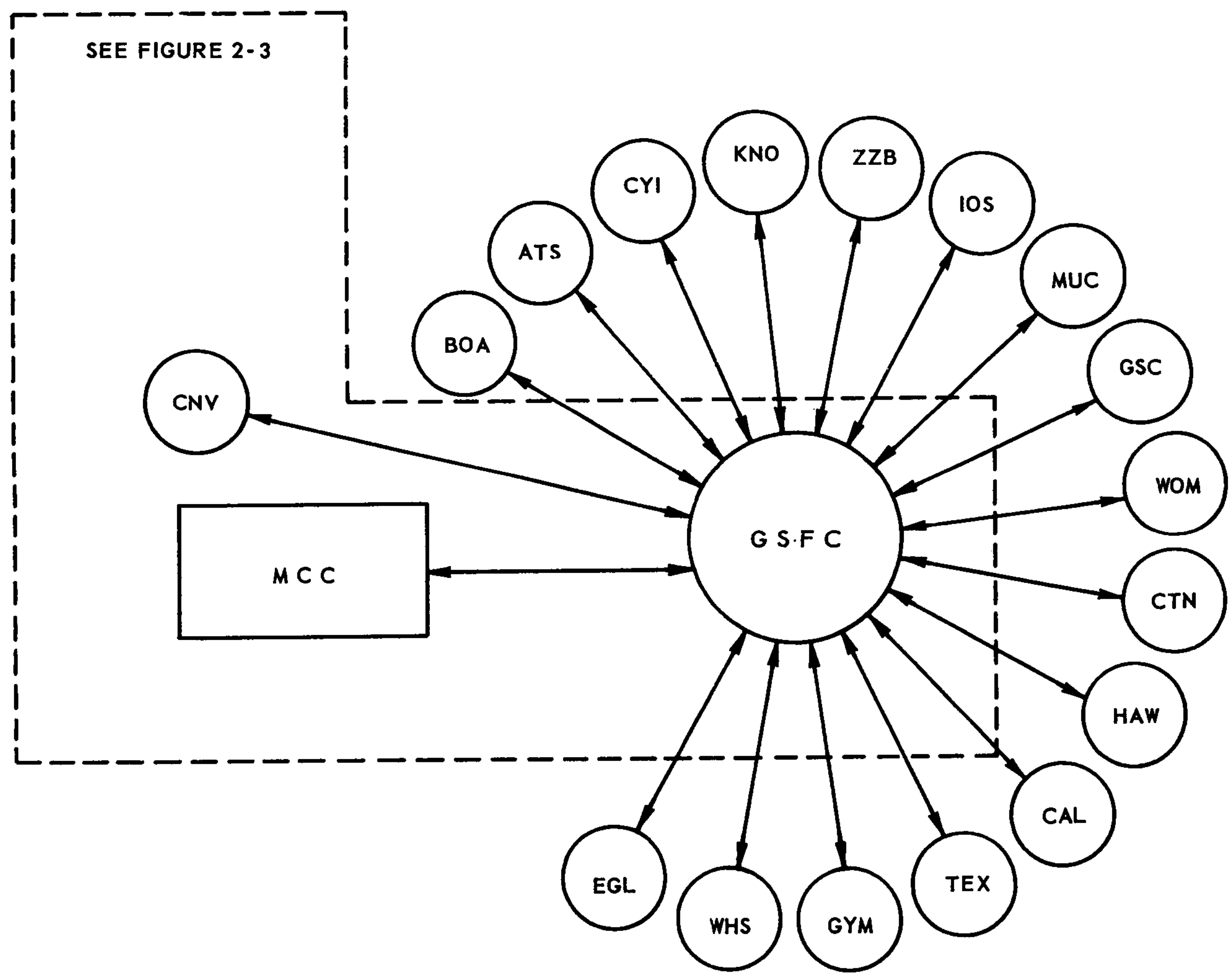

FIGURE 2–2. OVERALL MERCURY TRACKING AND GROUND INSTRUMENTATION SYSTEM DATA FLOW

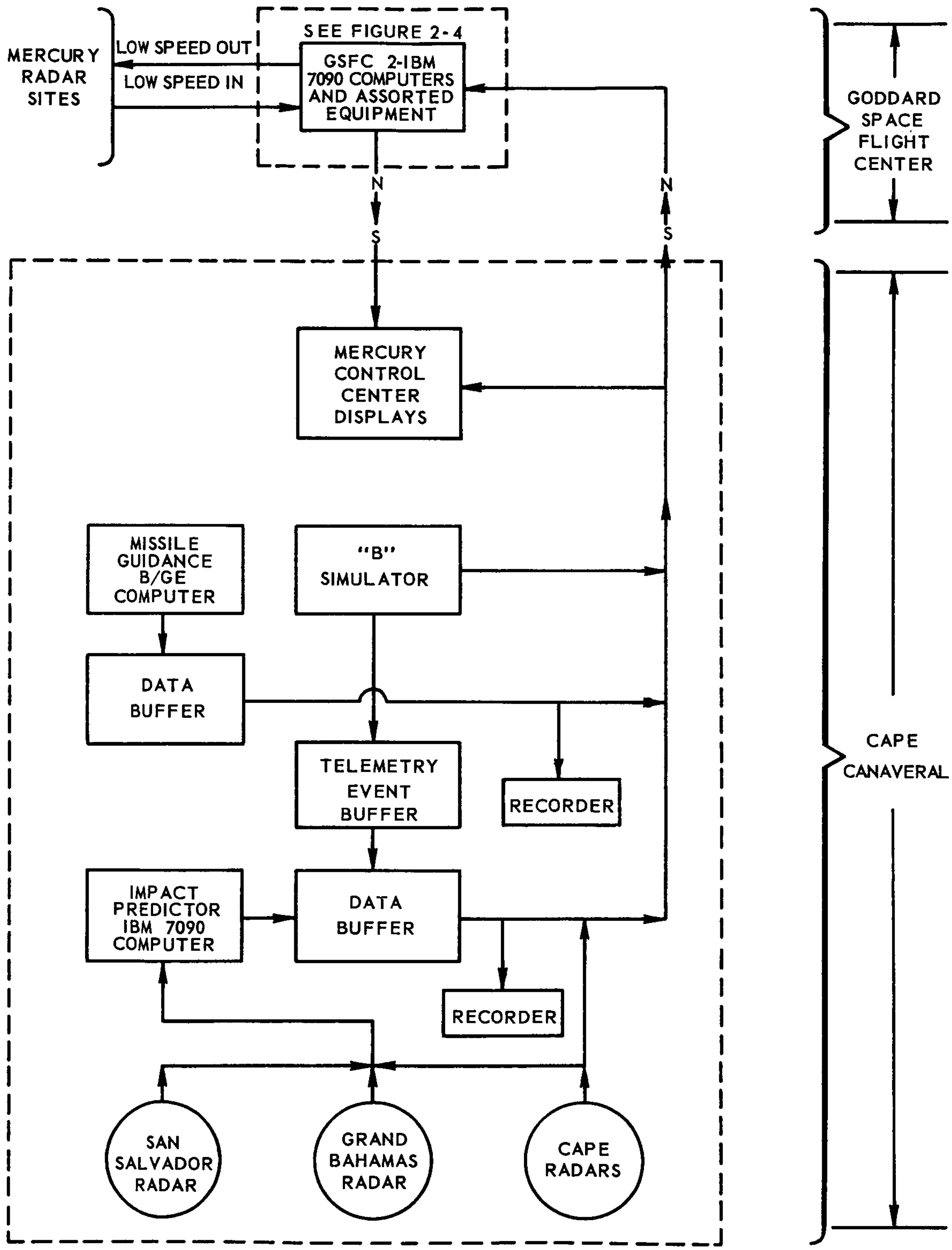

FIGURE 2–3. HIGH-SPEED DATA FLOW BETWEEN CAPE CANAVERAL AND GODDARD

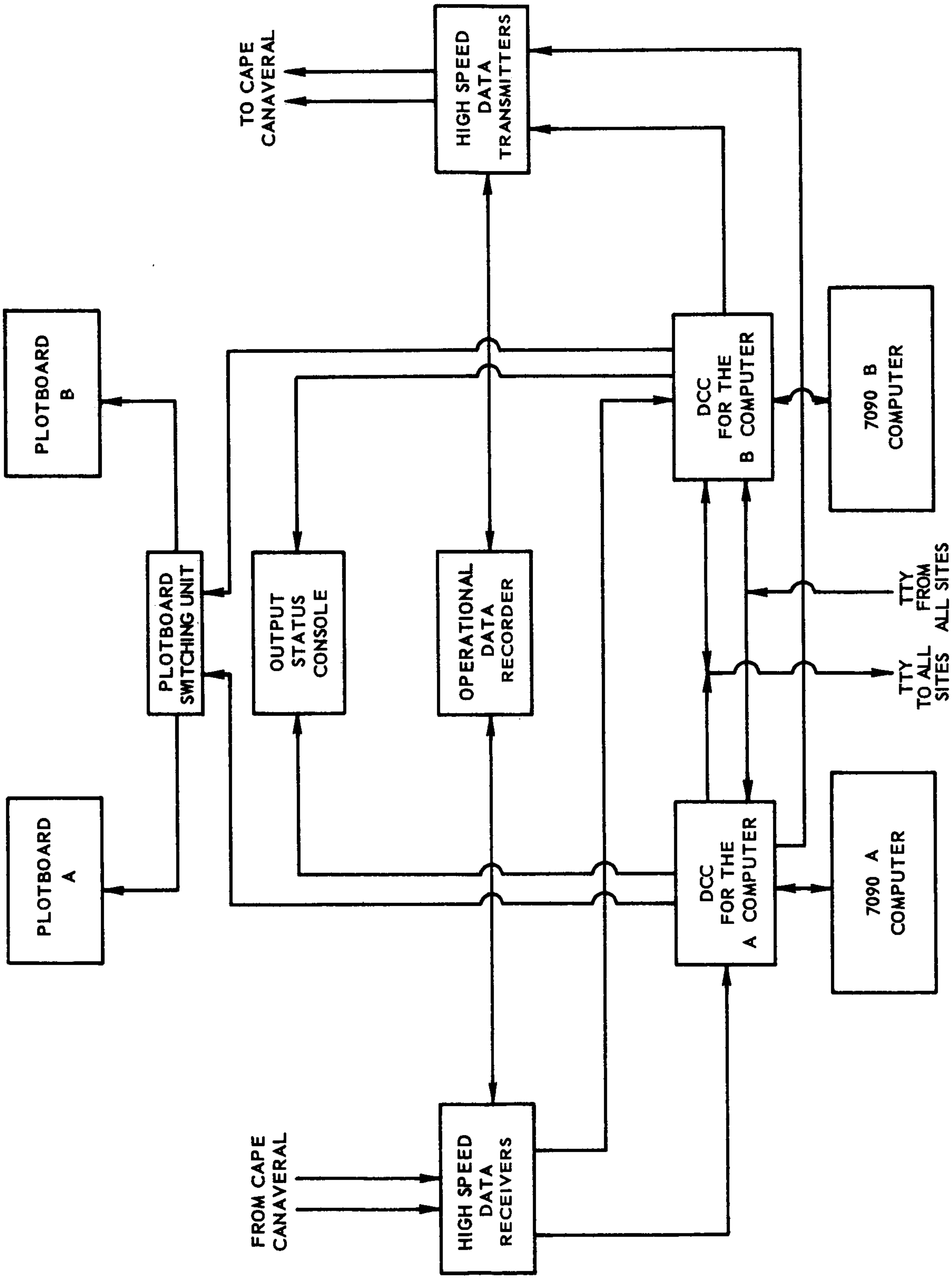

FIGURE 2-4. GODDARD SYSTEM DATA FLOW

2.1 SIMULATED TESTING

The simulated test is the first level of testing and is controlled by the Simulated Input/Output Control (SIC) program. This test is not run in real time, nor is there any dependence on any network components other than the program system, The Goddard computers and the Data Communications Channel (DCC) clock. The DCC clock is an internal timing device that steps once each milli-second of time and can be interrogated by the program for the purpose of synchronizing time with the operation of the program.

In this first level of testing, the input to the Mercury Program System is generated within the programming group. The procedure for generating this input is to first determine the true trajectory for a simulated run and then add radar random noise, transmission random noise, and pathological errors to this data. This provides the simulation tests with the most extreme operating condition under which the program system is expected to function. The simulated data is then written onto a magnetic tape which is then used as input data.

Since SIC exercises all controls over the program system, the operational program is in an artificial environment. SIC enters the information from the input tape to the Mercury Monitor program by maintaining control over the Monitor and by simulating the DCC, the device which normally supplies real-time data to the Monitor. The DCC clock enables SIC to maintain its sense of real time, thus supplying the simulated data at the corresponding times it would normally arrive in a real operation. The format, construction and methods used to prepare the input data; the different types of simulation programs used and the details concerning all phases of simulation are covered in, Computer Simulation Progams manual, MC 108.

An evaluation of the Mercury Program System based upon the simulated tests is limited to the program's logical structure and its capabilities in handling noisy and garbled data, inaccurate information regarding such items as site location, and the pressure of real-time problems. However, its unique feature of operating without the external inputs has made SIC an ideal vehicle for initial program testing.

Simulated testing provides many desirable features in program system testing not readily available in the other methods of testing. A few simulated testing features are:

a) Provides a vehicle for testing the interaction of the various processors within the structure of the Mercury Monitor program with input data under strict control of the programmer. It is possible to duplicate exact conditions, timing and data in case results are not as anticipated.

b) Provides intermediate results not displayed in the real-time operation of the program. This feature records for future analysis the behavior of any designated quantity, at or during, any pre-described time period. The intermediate results could consist of a large number of values produced at frequent intervals during the test. Each time SIC is called upon to produce these values, SIC suspends the operational program including the DCC clock, performs the necessary functions to obtain the values, and then returns to its former operating condition. An outgrowth providing for these intermediate results is that it requires more time for additional computations. For example, a launch trajectory of six minutes required 30 minutes of computer time.

c) Prevents undetermined equipment failures (occurring outside the computers) from contributing variables to the processing of a given set of data or from delaying the completion of such processing. Simulation testing provides a method of more easily isolating programming errors from network errors.

d) Relieves the Mercury range of the responsibility of supplying all the data sets necessary to the complete debugging of this large real-time system. Simulation testing eliminates the many problems involved when trying to coordinate the use and support necessary for network equipment.

e) Provides a means of altering the time required to accumulate the output data of any run. Since the processing of simulated test data is under program control, the time increment used in processing can be stepped at a faster than real-time rate, thus compressing the occurrence of the mission sequence. For example, a normal 90-odd minute single orbit mission required only 30 minutes of computer time when run in the simulated mode.

In theory, simulation provides any type of mission or data condition desired. This is accomplished by preparing a different input magnetic tape for each condition desired.

The output of a simulated test is no different from the output of the higher levels of testing. The simulation test can actually drive the output displays. Acquisition data and plotboard data can be presented locally, and the log tape that is written is no different in content, format, and construction than a log tape written during any other test or mission. Operational requirements of simulated tests are shown in Section 3.

2.2 UNSIMULATED TESTING

The unsimulated test forms the second level of system testing. The test does not operate under control of the SIC program as did the simulated tests, but demands the input data to be in real time and produces real-time outputs. The unsimulated tests are divided into local or remote inputs.

All of the input data in an unsimulated run enters the Goddard computers through the DCC (see Figure 2-5). The DCC has 30 subchannels which are used as input channels, output channels, or as timing channels. Subchannels 1 and 2 receive input data from the Burrough-General Electric (B–GE) and IP 7090 computers at Cape Canaveral respectively (see Figure 2–3). Subchannels 3 and 4 are output channels to local displays and to displays at Cape Canaveral. Subchannels 7, 8, and 9 are timing channels. Subchannels 10 and 11 are low-speed output and subchannels 14 through 27 are low-speed input channels from the world wide tracking network. Subchannels 29 and 30 are used at Goddard for the local insertion of simulated data.

Input data to the Mercury Program System is of two main types, 1) high-speed data received at a nominal rate of one message per 1/2 second, and 2) low-speed data received at a nominal rate of one message every six seconds.

High-Speed Data: This data is received during the launch phase of every Mercury mission and consists of a telemetry data summary and either position and velocity vectors with their associated time tag, or radar observations reflecting the trajectory of the launch vehicle. The requirement for real-time data regarding orbit capabilities makes the high message rate a necessity.

Figures 2–3 and 2–4 show the high-speed data input from Cape Canaveral arriving at Goddard in the high-speed data receivers and the high-speed data transmitters sending the output back to the Cape. The high-speed receivers and transmitters are "tied" to another unit called the Operational Data Recorder (ODR), which records, on magnetic tape, all information passing through the receivers or transmitters. The high-speed data source from Cape Canaveral is: 1) the IP 7090 computer or the Cape and downrange radars, 2) the B–GE guidance computer, or 3) the B-Simulator tape. If any of the above input data sources are once used in an unsimulated test, the data can be recorded on the ODR. The ODR also has the ability to read (or play back) what had previously been recorded.

Low-Speed Data: This data is received during the orbit, re-entry, and high-abort phases of all Mercury missions and consists of radar observations and their associated time tags. A sequence of data contained in these messages is used to refine an already defined orbit.

Figures 2–3 and 2–4 also show low-speed input data (sometimes called teletype data) arriving at Goddard from the Mercury radar sites. One such site is Goddard itself, where two teletype paper tape readers (ASR's) are located. The ASR's may be "patched" into the low-speed input channels of the DCC. The patching, in effect, makes the DCC and computer program think that this input is coming from one of the Mercury sites and the data received would be indistinguishable from live data.

2.2.1 Unsimulated Tests With Local Inputs

High-speed input data can be entered locally (at Goddard) by use of the playback feature of the ODR. Low-speed input data can be entered locally by inserting paper tapes into the ASR's. Unsimulated tests using local inputs are the most frequently used. The reasons are: 1) local input testing provides the means for establishing a large variety of conditions that could possibly occur during an actual mission, without the need of additional network support, 2) these tests utilize most

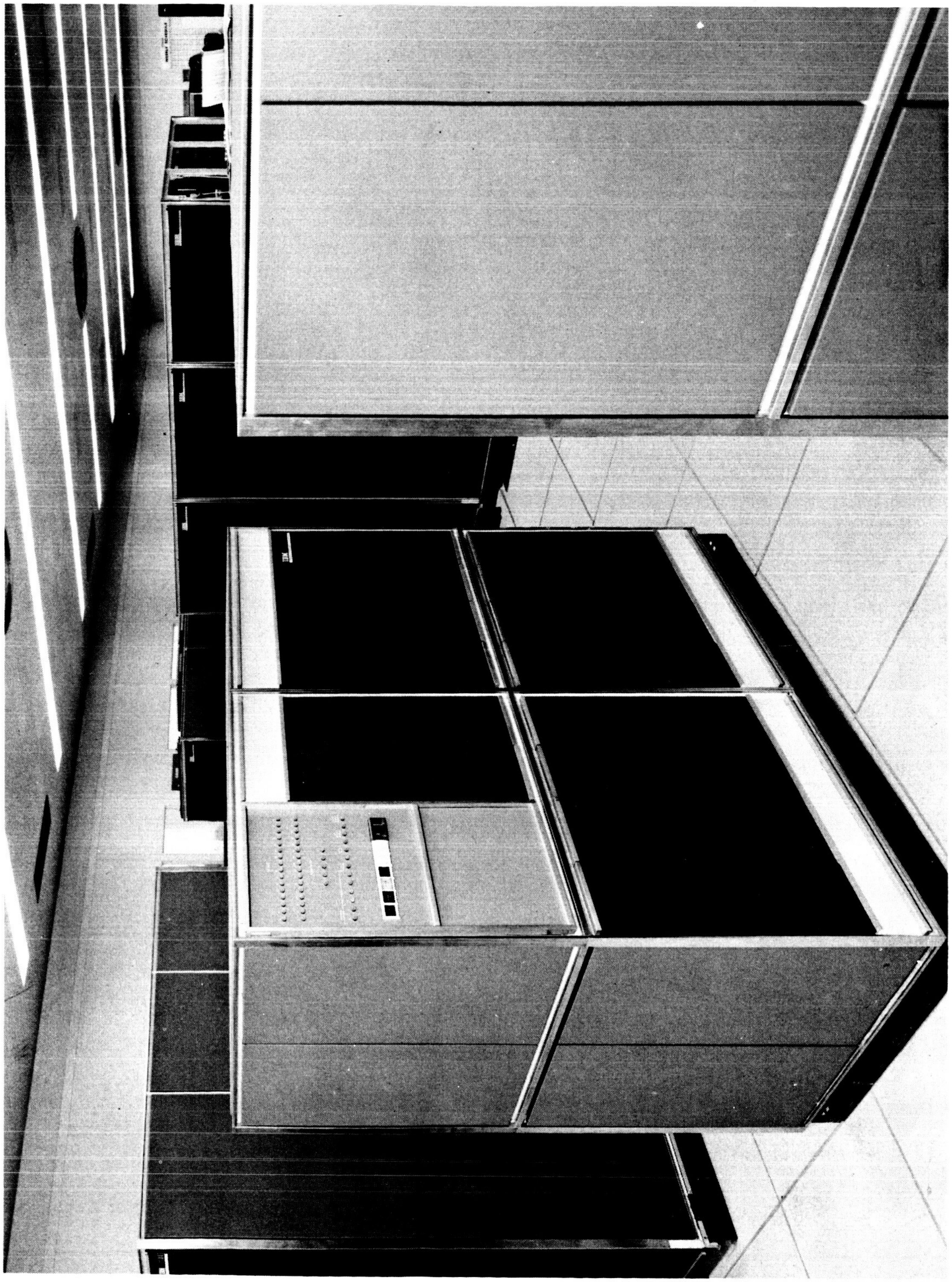

FIGURE 2–5. IBM 7281 I DATA COMMUNICATIONS CHANNEL

of the Goddard network, i.e., program, computer, DCC, high-speed receiver, and teletype equipment, and 3) these tests are run in real time and therefore provide a more realistic test to the Mercury Program System.

Any test where the high-speed input data originated from Cape Canaveral and was recorded on the ODR (Ampex Tape), is now available for any number of local tests. Following is a description of the recorded data and its source, which leads to a better understanding of how the ODR is used in unsimulated local testing.

The data recorded on the Ampex tapes consist of time, position, and velocity of the capsule. Also recorded, is the indication that a number of discrete events have taken place. These events are referred to as telemetry events and consist of 1) lift-off, 2) staging, 3) escape tower released, 4) tower escape rockets fired, 5) capsule released from sustainer, 6) one of three posigrades fired, 7) two of three posigrades fired, 8) three of three posigrades fired, 9) abort sequence initiated, 10) retro 1 fired, 11) retro 1 and 2 fired, 12) retro 1, 2, and 3 fired. The initial source of the position and velocity data during a mission would be the radars of the Cape complex and the source of the discrete events would be 1) the capsule via the telemetry receivers, 2) the launch pad, or 3) the vehicle telemetry system.

For necessary testing of the Mercury Program System, it would not be practical to always receive the input data "live" from a live mission, therefore means have been established to simulate the data. One of these means is by the use of a magnetic tape unit at Cape Canaveral referred to as the B-Simulator. The B-Simulator is used to transmit to Goddard any information that has been recorded on a magnetic tape. The B-Simulator unit contains information consisting of time, position, and velocity data of an arbitrary trajectory and in the same format as the data which would appear at the computer. The B-Simulator therefore can be, and is, used to simulate actual input data. The B-Simulator tape is prepared by a program called CLS1 (Closed Loop Simulation, Version 1) as described in Simulation Programs manual, MC 108. The latest version of this program is now called CLS3.

The means established to simulate the occurrence of the discrete events is a Telemetry Event Transmitting Buffer (T/M Buffer) and associated switches as described in Launch Monitor Subsystem manual, MS 124, Volume 2. The manual "throwing" of a certain switch indicates that a certain event, for example, lift-off, has occurred. By noting the time that the lift-off switch was "thrown," other switches, simulating other events are thrown after the proper elapsed time. For example, in a normal Mercury mission, tower separation would occur at approximately 158 seconds after lift-off and capsule separation would occur approximately 294 seconds after lift-off.

By preparing many different trajectory tapes for the B-Simulator and by manually throwing the telemetry event switch at different times, a variable number of test conditions can be produced. These test conditions can then be recorded on the ODR at Goddard for later playback and testing.

The other form of input data for local unsimulated tests is teletype (low-speed) data. The teletype data simulates the radar data that would arrive at Goddard from the various Mercury tracking sites. The data is in the form of paper tapes which have been punched from magnetic tapes prepared by the Simulation Programs. (See Computer Simulation Programs manual—MC 108). The paper tapes are then "fed" locally into the ASR's. Normally, the teletype circuitry is such that the computer program recognizes the input from one ASR as radar messages and the input from the other ASR as non-radar messages. However, for testing purposes, it is advantageous to have both ASR's connected in such a manner that both appear to have radar input. This is accomplished by patching the non-radar unit into one of the input lines from the sites. The data then passes through the circuitry, entering the input channel of the DCC and appearing to the computer program as it would if it had come from the station.

Each station at present has a specific assignment (see Table 2–1). This assignment could change, however, because it is conceivable that any station could come in on any DCC subchannel. Therefore, this program is intentionally very flexible and accepts data from any radar station coming in on any radar subchannel.

Since there are only two ASR's in the computer area, only two paper tapes simulating radar data can be "fed" to the program simultaneously. This does not completely simulate the actual mission because there may, at times, be more than two radar stations transmitting at the same time. However, testing with low-speed data permits the exercise of the program under a number of conditions more readily available than with the simulated test. These conditions can be such that the time at which data is "fed" can either approximate the actual time of reception or can be much later. Also, because there is direct and complete control over the data, the data itself can be varied in such a manner as to provide for any number of possibilities, i.e., word drop-out, interruption of transmission, and wrong data. The radar message format was chosen to ensure the reception of the maximum number of messages in case of equipment or circuitry problems.

The non-radar form of low-speed input data is manually inserted messages, specially prepared to indicate such information as the GMT of lift-off, abort phase, etc. There are six different messages defining critical pieces of information: 1) abort phase, 2) orbit phase, 3) GMT of lift-off, 4) number of retros fired, 5) position vectors time associated and 6) velocity vectors time associated. The format of these messages is shown in Table 3–2 (page 3–15).

There are certain times that these messages should be fed into the computer for local unsimulated operation. For example, the abort phase message causes the program to think that an abort has taken place and that now the program must go into the operation of computing re-entry data and refining the impact point of the capsule. Since an abort may take place at any time after lift-off, the program must be tested for low, medium, and high altitude abort cases. The time of entry, after lift-off, of this message creates the above conditions.

TABLE 2–1. DCC SUBCHANNELS AND TELETYPE LINE ASSIGNMENTS

Subchannel Number	Type	DCC Subchannel		
1	High-Speed	B–GE High-Speed Input		
2	Input	IP 7090 High-Speed Input		
3	High-Speed	Cape Canaveral High-Speed Output		
4	Output	Local High-Speed Output		
7		Half-Second Trap		
8	Timing	Minute Trap		
9		Interval Timer		
10	TTY	Through PRO 117 to WOM, MUC, HAW, GYM, TEX, BDA, ATS, CYI, KNO, USAFI		
11	Output	Through PRO 118 to HAW, CTN, WOM, MUC, IOS, CAL, WHS, EGL, BDA, CNV, KNO, CYI, ZZB, USAFI		
		Line No.	ROTR (S/P)	Stations
14		7005–11	13	CNV
15	TTY	7005–9	1	BDA
16	Input	USAFI	2	BDA
17		7005–10	5	BDA
18		7005–17	14	CYI, ZZB, KNO
19		7005–02	7	MUC, CTN, WOM, HAW
20		7005–04	9	CAL
21		7005–06	10	WHS
22		7005–08	12	EGL
23		7005–16	3	ATS, CYI
24		7005–01	6	IOS, WOM, MUC
25		7005–3	8	HAW
26		7005–5	4	GYM, MEX
27		7005–7	11	TEX
28		—	15	(Spare)
29		—	16	ASR 141 Manual Radar Insertion
30		—	17	ASR 140 Manual Non-Radar Insertion

The results of the unsimulated local tests are determined by: 1) on-line messages, (see Subsection 2.4), 2) log tape results (see Subsection 2.3), and 3) local plotboards. The Goddard plotboards are used to plot some of the same data that is plotted at Cape Canaveral. There are four plotboards at Cape Canaveral and depending upon the flight phase (launch, abort, orbit, or re-entry), transmissions concerning the behavior of the vehicle are plotted on these boards. The program is designed to "trap" the Cape Canaveral output for certain data and display it on the local plotboard. This display data is then compared against known data to determine the accuracy of the computing program.

2.2.2 Unsimulated Testing With Remote Inputs

Remote unsimulated testing is a higher level of testing than simulated or local unsimulated testing and is the last level of testing controlled by Goddard. The equipment used for remote testing is the same equipment and circuitry used during an actual launch. This in effect, tests the program, the network components, and the interaction between them. The remote unsimulated tests are not performed as frequently as the local unsimulated tests for three reasons: 1) the Cape computers are also being used for missions other than Project Mercury, 2) once data from the Cape computers is played, it is recorded at Goddard for additional local unsimulated testing, and 3) the Cape radars and computers can be simulated with other equipment. Simulation of the IP 7090 and B–GE computers can occur at the data buffers (see Figure 2–3). This is accomplished by playing a tape representing the computed data from either one of the buffers. Simulation of raw radar data can be accomplished in a similar manner with taped recording of radar data transmitted from the radar site up the high-speed lines to Goddard.

Finally, any of the raw or computed data inputs can be simulated with the B-Simulator as described in Subsection 2.2.1, Unsimulated Tests With Local Inputs. This means that any launch trajectory anticipated can be simulated and tested without a great deal of support and coordination, a highly desirable situation for the number of tests that must be made.

The input data for remote tests originates at a source outside the Goddard complex. For high-speed input data, the source is Cape Canaveral and for the low-speed input data, the source is the Mercury radar sites. However, the term remote testing does not always imply that the entire input is from remote sites. Sometimes only one site (Cape Canaveral) is the source of data and additional data if needed is supplied locally. The larger the number of sites involved, the greater is the need for coordination, scheduling and manpower requirements.

High-speed input data consists of three different types: 1) IP 7090 computed data, 2) B–GE computed data, and 3) raw radar data. The IP 7090 computed data is actually position and velocity radar data that has been "processed" by the IP 7090 computer and then transmitted to Goddard. The IP 7090 receives its input from a radar or a previously prepared magnetic tape. When a magnetic tape is used as input, the radar output is simulated, thus eliminating the need of the radar, its associated equipment and personnel. In similar manner, the B–GE computer is used to "process" its input and then transmit the data to Goddard.

Raw radar data can be transmitted to Goddard from the Cape radars or the down range radars at San Salvador and Grand Bahamas Island. When the radars or computers are used as the source of input data, it is necessary to have the Mercury Control Center enter the necessary telemetry events, i.e., lift-off, capsule separation, etc., as they might occur during a mission.

Low-speed data for remote unsimulated testing originates at the Mercury range sites. The data is actual radar data or a previously prepared paper (teletype) tape simulating radar data. Transmission of this data is via the data links (Worldwide Communication Network) through the teletype communication circuitry and to the computers at GSFC. When low-speed data arrives at Goddard via the Communication Network, there will be, as expected, some transmission errors. Those errors occur as a result of circuitry transmission and propogation difficulties experienced in communications throughout the world. As a result of this, the program must be tested to "pick out" good data and disregard the errors. A normal low-speed transmission consists of 50, 60, or 70 radar messages. The computer program will then print on-line, for monitoring purposes, the number of messages acceptable.

There are two types of output for unsimulated remote testing that do not occur under the other modes. These are high-speed output to Cape Canaveral and low-speed acquisition messages to the Mercury sites. The high-speed output to Cape Canaveral "drives" the plotboards and digital displays. The low-speed output is "look" angles and position data.

If the results of the output (displays and data) is monitored, there is a real time indication that everything involved is or is not functioning correctly. This is the greatest advantage of remote tests. In describing the means of system testing by levels, 1) the simulated tests, 2) unsimulated with local inputs and, 3) unsimulated with remote inputs; one other type of test should be mentioned—the Network Drills. Not only are the Network Drills a test of the programming system, but of the entire Mercury Tracking Range and all equipment, circuitry, interface reaction and personnel involved in an actual mission. In a Network Drill, Goddard is only one of many sites; the operational program is merely one sub-item of everything required. Control over the Network Drills is exercised by a Network Control group. The drills exercise the program in an unsimulated mode impossible to duplicate in any other way. This, in effect, is the highest level of testing attainable and one which comes closer than any other to approximating an actual mission.

2.3 LOG TAPE ANALYSIS

The log tape, with the external routines, evaluates the Mercury Program System under test irrespective of the amount of equipment involved.

A log tape is prepared during the running of any portion of the Mercury Program System whether it be real time, simulated, local unsimulated, or remote unsimulated. The tape contains (in binary form) all input and output data to and from the Goddard computers via the Data Communications Channel (DCC).

The data recorded on the log tape is the result of the DCC and computer operation. The DCC, which is the connecting link between the outside world and computer, has a data buffer associated with every input and output channel. The buffer is a small intermediate storage unit. The incoming and outgoing data is stored in the buffer until it becomes full, at which time the DCC signals the computer that either a high-speed or low-speed buffer is full and the data needs processing. The computer stops its computations and transfers to a different location and proceeds to process the data. This automatic transfer is known as "trapping." The Mercury Program System is coded in such a manner that whenever an input or output trap occurs, the contents of the buffer causing the trap are recorded on the log tape. Thus, the log tape contains all input and output message formats as received and transmitted by the DCC. The input messages are high-speed position and velocity data from either 1) the radars or computers at Cape Canaveral or 2) low-speed data from one of the Mercury range sites. The output messages are 1) high-speed data driving plotboards or displays at Cape Canaveral or 2) low-speed acquisition messages to the Mercury radar sites.

The external routine HSIN5 and the routines MXPRLG and MXHSPR (as described in External System Programs manual, MC 107) decode the information from the log tape and scale and arrange it for off-line printing. In operation, all the output formats of the three logging routines are printed on one line. However, for presentation purposes some of these formats had to be divided into two or three lines. A brief discussion on the operation of these routines follows.

2.3.1 High-Speed Input Program (HSIN5)

The external routine HSIN5 examines a log tape for high-speed IP 7090, B–GE, or raw radar input messages. The original source of the data could have been either real or simulated. For example, if an examination of the B–GE computed or B-Simulator data that was used as input for a test is required, HSIN5 extracts this information from the log tape. Where the input had previously been recorded (B-Simulator) and known, there is no verification that some type of transmission error had not occurred and that now the data is not the same as had been recorded. For this reason, it is important in systems testing to know exactly what input was used by the Mercury Program System. An example of the output of HSIN5 is shown below.

LOGGING MESSAGE

L–TIME	M–TIME	X	Y	Z
46206 782	11.464	0.9203384	0.0005558	0.4961522
26206.782	11.464	0.9203384	0.0005558	0.4961522
46207.282	11.964	0.9203424	0.0005558	0.4961543
46207.282	11.964	0.9203424	0.0005558	0.4961543

X	Y	Z	Discreet Signals	Checksum	Parity
0.0054533	0.0505543	0.0030203	371	0	1
0.0054533	0.0505543	0 0030203	371	0	1
0.0057228	0.0505543	0.0031700	371	0	1
0.0057228	0.0505543	0.0031700	371	0	1

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	1	2	3
1	1	1	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
1	1	1	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
1	1	1	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
1	1	1	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1

The heading on each output page printed indicates IP 7090, B–GE, or raw radar input followed by a heading above each column. An explanation of the column headings follows.

Logging Time—This is time in seconds as shown by the internal clock of the DCC. If the internal clock were synchronized with Greenwich Mean Time (GMT), as is the case, this column then shows GMT. In the example above, the time at which the message was logged is 46206.782 seconds or 12 hours, 50 minutes and 6.75 seconds GMT.

Message Time—This is the time associated with each of the incoming position and velocity vectors. It is incorporated within the input message. In the example shown, the time of the position and velocity vectors is 11.464 seconds after lift-off.

X, Y and Z indicate the X, Y and Z components of the position vector using the appropriate units of the input source.

$\dot{X}$, $\dot{Y}$, and $\dot{Z}$ indicate the X, Y and Z components of the velocity vector in appropriate units of the input source.

Discrete Signals—This column is an octal representation of 8 binary bits. Each of the binary bits is contained somewhere within the input message. The first bit indicates if lift-off has occurred, the next four bits are data quality flags, the next two bits indicate if Booster Engine Cut-off (BECO) and Sustainer Engine Cut-Off (SECO) respectively has occurred and the last bit gives the GO, NO-GO recommendation as computed by the B–GE computer.

Checksum—This column is zero if the checksum in the input message is identical to the checksum computed. Otherwise, a 1 is shown in this column.

Parity—The format of the correct input message is such that parity is always odd indicated by a 1 in this column. A zero in this column indicates incorrect parity.

The last column headed by the alphabet A through Z and the numbers 1, 2 and 3 is a column of 29 numbers, each being either a one or zero, indicating telemetry signals. A one indicates affirmative action and a zero negative action. Columns A, B, and C indicate if posigrades 1, 2, and 3 have fired. Columns D, E, and F indicate if retros 1, 2, and 3 have fired. Column G indicates if lift-off has occurred. Column H indicates if tower separation has occurred. Column I—escape rockets. Column J—capsule separation. Column K—abort initiate. Column L—abort phase. Column M—orbit phase. Column N—B–GE data selected. Column O—simulated SECO. The remaining 14 columns (P through 3) are a repeat of the seven former signals (G through M) which are in triplicate in the message. However, the sequence is recorded in reverse order (M back through G) in columns W through 3.

In the above example, columns A, B, and C indicate that posigrades 1, 2 and 3 have fired. Columns G, P and 3 indicate that lift-off has occurred and column N indicates that this is B–GE data as the selected source rather than IP 7090 or raw radar data.

2.3.2 Low Speed Input-Output Printer Program (MXPRLG)

The MXPRLG routine extracts the low-speed input and output messages from the log tape and arranges it in readable form. If, for example, a remote unsimulated test was being performed, there is no way of knowing the content of the data from a station, such as Hawaii, except by recording it as received. The data passes through many transmission links and much equipment from its origin to the computer. Because of the "real-time" nature of Mercury network, the best available means of determining the content of the low-speed input is by use of the log tape. There are teletype monitors placed in the transmission circuits to monitor the information passing through the circuit. However, the necessary placements of the monitors is such that they cannot record the exact data as used by the computer program. The monitor also records the data on paper tapes, which would have to be further processed in some manner to extract the usable information. An example of the output of MXPRLG is shown on the following page.

GODDARD TELETYPE INPUT

INDENTIFICATION
29

Station Number	Radar Type	Validity	Hours	Minutes	Seconds	Azimuth	Elevation	Range
04	2	2	00	14	42	313663	001671	0432621
04	2	2	00	14	48	313622	002100	0421242
04	2	2	00	14	54	313621	002413	0407714
04	2	2	00	15	00	313537	002642	0376356
04	2	2	00	15	06	313526	003106	0365024

GODDARD TELETYPE OUTPUT

IDENTIFICATION 11 TERMINAL DATA IS TRANSMITTED

YNYN
114800Z

CYI
AQ

11	54	31	1555	287.5	.8
11	55	58	873	286.1	9.6
11	57	04	382	280.8	30.4
11	57	58	237	134.1	58.8

114800Z
CYI

In the input format example, the data was received through DCC subchannel 29. Each line following the subchannel identification indicates a low-speed radar message, in the format as defined by the specifications. Each message contains the station identification code, the type of radar used (Verlort or AN/FPS-16), the time, range, azimuth, and elevation of the capsule position and whether the data is valid or invalid.

The first line of the output example contains the heading words IDENTIFICATION, TERMINAL, and DATA IS TRANSMITTED. Immediately under the word IDENTIFICATION is a number corresponding to the DCC subchannel through which the data passed and was subsequently logged.

In the output format example, the data was transmitted through DCC subchannel 11. The left column contains the communication switching letters (YNYN), the GMT time in hours, minutes and seconds, the terminal station letters, and the type of transmission (AQ meaning acquisition). Following the type of transmission is message content consisting of 4 "look" angles; each consisting of time, range, azimuth, and elevation.

2.3.3 High-Speed Output Printer Program (MXHSPR)

The MXHSPR program is used to extract the high-speed output messages from the log tape. During any Mercury Program System test, it is very difficult to monitor 25 or 30 different quantities in real time. The quantities, as previously described, are data shown on plotboards, strip charts, and digital displays. The quantities present at any instant of time, the actual and expected action of the missile as computed by the Mercury Program System. Also shown are computational suggested courses of action to be taken by the Flight Controllers, who must make decisions concerning the flight of the missile. So, with MXHSPR, one can print the output messages and immediately upon conclusion of any test analyze every value transmitted and determine if the transmitted data is correct.

The following examples of MXHSPR output show the computed values transmitted to Cape Canaveral to drive plotboards 1, 2, and 4 and the digital displays (during launch plotboard 3 is not driven from Goddard). MXHSPR searches the log tape for values transmitted to, for example, plotboard 1 at Cape Canaveral during the launch phase. These values are then assembled and printed under the heading LAUNCH PHASE—PLOTBOARD ONE as shown below.

LAUNCH PHASE — PLOTBOARD 1

γ	V/V_r (less than .19)	γ	V/V_r (less than .9)
.00000000	.03999999	.00000000	.00000000
.00000000	.03999999	.00000000	.00000000
.00000000	.03999999	.00000000	.00000000
.00000000	.03999999	.00000000	.00000000
.00000000	.03999999	.00000000	.00000000
.00000000	.03999999	.00000000	.00000000

LAUNCH PHASE — PLOTBOARD I (Cont'd)

TIME	γ	V/V_r (greater than .9)
	−.99999809	.89999998
	−.99999809	.89999998
1	−.99999809	.89999998
1	−.99999809	.89999998
2	−.99999809	.89999998
2	−.99999809	.89999998

Plotboard 1 shows flight path angle γ and velocity ratio V/V_r associated with a TIME column. TIME is in seconds after lift-off. Because of plotboard scaling three columns of both γ and V/V_r are shown.

The same operation is performed for the other plotboards and displays during the launch phase. MXHSPR also searches the log tape for the values displayed during the orbit phase. The values are assembled and printed under the heading ORBIT PHASE. Sub-headings are printed for each of the plotboards, wall map and digital displays as noted in the examples.

Some displays, for example plotboard 1, show different quantities during the launch and orbit phases. During launch, plotboard 1 shows flight path angle γ vs. velocity ratio (V/V_r), and during orbit it shows altitude vs. velocity.

The example for plotboard 2 shows cross-range deviation $(Y - Y_{nom})$ and down-range distance D (D less than 60). TIME is in seconds after lift-off and additional columns of down-range distance, height H (D less than 60) are shown because of scaling.

LAUNCH PHASE — PLOTBOARD 2

$Y-Y_{nom}$	D (D less than 60)	H (D less than 60)	TIME	D (D greater than 60)	H (D greater than 60)
.05865091	.00000000	.00000000	1	.00000000	.00000000
.05865091	.00000000	.00000000	1	.00000000	.00000000
.05865091	.00000000	.00000000	2	.00000000	.00000000
.05865091	.00000000	.00000000	2	.00000000	.00000000
.05865091	.00000000	.00000000	3	.00000000	.00000000

The first two columns of the plotboard 4 example show the latitude and longitude of the impact point during launch if the firing of the retrorockets was withheld until the capsule reached an altitude of just above 450,000 feet. The next two columns show the impact point if the escape rockets were fired immediately. Also, if tower separation has already taken place, then these columns show impact point if retrorockets are fired 30 seconds from present time. The column TIME indicates time in seconds associated with each set of values.

LAUNCH PHASE — PLOTBOARD 4

LATITUDE (maximum)	LONGITUDE (maximum)	LATITUDE (30 seconds)	LONGITUDE (30 seconds)	TIME
11.99999809	—.00586510	28.49266434	—80.50439835	
11.99999809	—.00586510	28.49266434	—80.50439835	
11.99999809	—.00586510	28.49266434	—80.50439835	1
11.99999809	—.00586510	28.49266434	—80.50439835	1
11.99999809	—.00586510	28.49266434	—80.50439835	2

The following example shows the values transmitted to the wall map at Cape Canaveral and the time in seconds after lift-off that the transmission occurred. It shows latitude, longitude and time (present position) of capsule.

LAUNCH PHASE — WALL MAP

LATITUDE (P.P)	LONGITUDE (P.P)	TIME
28.50439644	—80.41055679	
28.50439644	—80.41055679	
28.50439644	—80.41055679	1
28.50439644	—80.41055679	1
28.50439644	—80.41055679	2

Data transmitted to the strip charts (see the following example) is the result of computed values (as a result of input) versus nominal values. The first column is $\gamma - \gamma_{nom}$ from B-GE data. The second column would be the same $(\gamma - \gamma_{nom})$ for either IP 7090 or raw radar data whichever is the selected source. The next two columns show the difference in velocity ratios $\left[\frac{V}{V_r} - \frac{V}{V_r}\text{ (nominal)}\right]$ for B-GE and the IP 7090. The TIME column contains time in seconds after lift-off.

LAUNCH PHASE — STRIP CHARTS

$\gamma - \gamma_{nom}$ (B-GE)	$\gamma - \gamma_{nom}$ (AN/FPS-16)	$V/V_r - V/V_{r\,nom}$ (B-GE)	$V/V_r - V/V_{r\,nom}$ (AN/FPS-16)	TIME
—.00488663	—.00488663	—.00003913	—.00003913	
—.00488663	—.00488663	—.00003913	—.00003913	
—.00488663	—.00488663	—.00003913	—.00003913	1
—.00488663	—.00488663	—.00003913	—.00003913	1
—.00488663	—.00488663	—.00003913	—.00003913	2

The output of MXHSPR to some of the digital displays during launch is shown below. Following these examples is a glossary of the column headings:

LAUNCH PHASE — DIGITAL DISPLAYS

Δ T	Recovery Area	TIME
00 00 00	0 0	
00 00 00	0 0	1
		1
00 00 00	0 0	2
		2
00 00 00	0 0	3
		3
00 00 00	0 0	4

$r - \bar{R}$	γ	I.A.	O.C.	V/V_r
000.0	00.00	00.0	00	0.0000
000.0	00.00	00.0	00	0.0000
000.0	00.00	00.0	00	0.0000
000.0	02.30	28.3	00	0.0510
000.0	02.78	28.3	00	0.0511

ΔT — This column indicates elapsed time to fire retrorockets to impact in next recovery area.

RECOVERY AREA — This column will contain two numbers:
- 00 — Recovery Area A
- 01 — Recovery Area B
- 02 — Recovery Area C
- 03 — Recovery Area D
- 04 — Recovery Area E
- 11 — Recovery Area IB

TIME — Time in seconds after lift-off:
$r-\overline{R}$ — Height in miles
γ — Flight path angle in degrees
I.A. — Inclination angle
O.C. — Orbit capability
V/V_r — Ratio of velocity to velocity required

Examples of values transmitted to Cape Canaveral during the orbit phase, logged on the log tape, and subsequently printed by MXHSPR are shown below. A glossary of unexplained column headings follows the examples.

ORBIT PHASE — WALL MAP

LATITUDE (P.P.)	LONGITUDE (PP)	LATITUDE (R.F. in 30 sec)	LONGITUDE (RF in 30 sec)	TIME
30.85043907	—69.85337257	—.03910065	—.17595291	5 30
30.92863846	—69.50146675	—.03910065	—.17595291	5 36
31.00684166	—69.14955902	—.03910065	—.17595291	5 42
31.08504295	—68.79765511	—.03910065	—.17595291	5 48

ORBIT PHASE — DIGITAL DISPLAYS

GTRS	ORBIT NO.	GMTLC	LATITUDE	LONGITUDE	$r-\overline{R}$
04 28 02	01	20 02	19.36	—065.0	092.9
04 27 50	01	20 02	19.36	—065.0	092.9
04 27 36	01	20 02	19.36	—065.0	092.9
04 27 26	01	20 02	19.36	—065.0	092.9
04 27 14	01	20 02	19.36	—065.0	092.9

APOGEE HT.	I.A.	ORBIT CAP.	TIME	VELOCITY
124.9	32.4	00	5 36	25660
124.8	32.4	00	5 48	25660
124.8	32.4	00	6 2	25660
124.7	32.4	00	6 12	25660
124.7	32.4	00	6 24	25660

ORBIT PHASE — DIGITAL DISPLAYS

GMTRC	ECTRC	GMTRC EPO	ECTRC EPO	GMTRC–EOM
15 33 21	00 19 36	16 41 38	01 27 53	19 46 39
15 33 21	00 19 36	16 41 38	01 27 53	19 46 39
15 33 21	00 19 36	16 41 38	01 27 53	19 46 39
15 33 21	00 19 36	16 41 38	01 27 53	19 46 39
15 33 21	00 19 36	16 41 38	01 27 53	19 46 39

ECTRC–EOM	GMTRS	ICTRC	RECOVERY AREA			TIME
04 32 54	19 47 23	00 —01	16	1	1	6 6
04 32 54	19 47 23	00 —01	16	1	1	6 18
04 32 54	19 47 23	00 —01	16	1	1	6 30
04 32 54	19 47 23	00 —01	16	1	1	6 42
04 32 54	19 47 23	00 —01	16	1	1	6 54

ORBIT PHASE — PLOTBOARD 1

ALTITUDE	VELOCITY	TIME
92.86412510	25659.82404041	5 30
92.86412510	25659.82404041	5 36
92.86412510	25659.82404041	5 42
92.86412510	25659.82404041	5 48

ORBIT PHASE — PLOTBOARD 2

$r - \overline{R}$	TIME	ALTITUDE	TIME
109.09090826	334.31069946	93.25513181	5 30
109.09090826	334.31069946	93.25513181	5 36
109.09090826	334.31069946	93.25513181	5 42
109.09090826	351.90599918	93.25513181	5 48
109.09090826	351.90599918	93.25513181	5 55

ORBIT PHASE — PLOTBOARD 3

PERIGEE LONGITUDE	ELAPSED TIME	ECCENTRICITY	TIME
−92.02346039	334.31069946	.00464514	5 30
−92.02346039	334.31069946	.00464514	5 36
−92.02346039	334.31069946	.00436363	5 42
−91.31964874	351.90599918	.00436363	5 48
−91.31964874	351.90599918	.00436363	5 55

ORBIT PHASE — PLOTBOARD 4

LATITUDE (P.P.)	LONGITUDE (P.P.)	LATITUDE (I.P.)	LONGITUDE (I.P.)	TIME
30.86216545	−69.98533821	11.99999809	−45.00000191	5 30
30.95600700	−69.54545593	11.99999809	−45.00000191	5 36
31.02638817	−69.10557365	11.99999809	−45.00000191	5 42
31.09676933	−68.66569138	11.99999809	−45.00000191	5 48
31.19061089	−68.13783073	11.99999809	−45.00000191	5 55

A — semi-major axis of orbit of capsule
R — nominal radius of earth
Time — Time is shown in seconds or minutes and seconds since lift-off
Perigee — lowest point of orbit
Eccentricity — Eccentricity of orbital ellipse
Long.R.F. — Longitude if retro fire in 30 seconds
GTRS — Elapsed time to retro setting
GMTLC — GMT of landing (computed)
$(r-\overline{R})$ — Altitude
Apogee — Farthest point of orbit
GMTRC — Greenwich Mean Time of retrofire computed
ECTRC — Elapsed capsule time of retrofire computed
ECTRC−EPO — Elapsed capsule time of retrofire computed, end present orbit
GMTRC−EOM — GMTRC at end of mission
GMTRS — Greenwich Mean Time of retro setting
ICTRC — Incremental time of retrofire computed

2.4 ON-LINE MESSAGES

During the operation of any type of Mercury Program System run—real, simulated or unsimulated—certain messages are printed on the computer's attached printer (called on-line messages) to assist the Test Director in the monitoring and evaluation of the test. These messages in general indicate the progress of the tracking program, thereby enabling the Test Director to make comparisons with known factors to establish the correctness of the computer progress. For example, the message "TOWER SEPARATION SIGNAL HAS BEEN RECEIVED" is printed on-line when the computer receives a signal indicating that this event has taken place. If the Test Director or personnel monitoring the on-line messages know the approximate time at which this event should occur and the computer program's reaction to the event, decisions concerning the correct operation of the program can be made.

There are approximately 270 messages written on a magnetic tape called the "MESSAGE TAPE". Each message has associated a corresponding number. Whenever it is desired to print one of the messages, the corresponding number is selected by proper programming and a search made of the message tape until this number is found. The selection of the number is known as "queueing". At many points throughout the operational program, a "que" is located to select and print a certain message on the printer. That is, the processors that constitute the Mercury Program System have several paths, each path resulting from different conditions being imposed upon the system. Each path has one or more "ques" and associated messages indicating that this particular sequence of events is occuring. When a message is printed, there is a positive indication that this particular operation has occurred. Also, at the time of printing, the DCC clock is monitored, and the Greenwich Mean Time at which the printing occurred is printed with the message. Since the messages indicate the conditions in the program, either correct or incorrect, and the time of occurrence, the Test Director or Message Monitors can make an immediate evaluation of the program or they can retain the on-line printouts for later analysis.

A typical example of the on-line message printed within the first few minutes of a nominal run is shown in Table 2–2.

The first message printed at time 09.03.00 (GMT) indicates that the Mercury Program System has been loaded into the computer correctly and normal operation of the program begun. The computer's clock has been synchronized with a time standard (WWV). At 09.03.22 an updated tape containing the latest values of each of the Mercury stations has been inserted into the program. At this point the program is ready to accept any and all data arriving from any of the Mercury stations. The next three messages indicate that the data the program is receiving is invalid and the program is rejecting it. This is as expected, since any data arriving before the mission is actually under way (Lift-off signal) would be invalid. At 09.05.07 a message is printed indicating that lift-off had occurred at 09 hrs. 05 mins. 00 seconds GMT. Each minute of time after lift-off, a message is printed indicating the expected and actual number of high-speed output messages that are driving the Cape displays. If the expected and actual numbers agree and are 120, the latest in-

TABLE 2–2 EXAMPLE OF ON-LINE MESSAGE PRINTOUTS

GMT MESSAGE IS PRINTED	MESSAGE
09.03.00	Normal operation begun
09.03.04	The WWV time entered is (GMT) 09 hrs 03 mins 00 secs
09.03.22	Station characteristics tape has been read successfully
09.04.01	High-speed output transmission rate to Cape expected, 120, actual 83
09.04.10	Line two low buffer telemetry rejected
09.04.15	Line two high buffer telemetry rejected
09.05.07	The time of lift off is (GMT) 09 hrs 05 mins 00 secs
09.06 05	High-speed output transmission rate to Cape, expected, 120, actual 120
09.07.04	High-speed output transmission rate to Cape, expected, 120, actual 120
09.07.36	Tower separation signal has been received, 154
09.07.53	Bermuda AN/FPS–16 Acquisition data sent
09.08.01	High-speed output transmission rate to Cape, expected, 120 actual 120

formation concerning the action of the missile, as computed from the input data arriving, has been presented to the Cape displays each 1/2 second in time. At 09.07.36 the Tower Separation signal was received and noted and at 09.07.53 the first of four messages was sent to Bermuda. The messages going to Bermuda contain time, range, azimuth and elevation and are "look" angles—giving a point in time at which the Bermuda radars could expect to find the capsule. At 09.08.01 another minute has passed with all indications of the beginning of a successful mission. The messages will continue, spelling out the operation of the computer program and the progress of the mission.

Table 2–3 contains the messages on the Message Tape, their associated number and the processor in which the "que" of each message occurs. Most of the messages are self-explanatory, however, there is an explanation of the ones that may be doubtful following the message in the list. Details concerning the reasons the messages are printed are included in the Goddard Monitor Program manual, MC 103.

TABLE 2–3 ON-LINE MESSAGES

MESSAGE NO.	MESSAGE	USED BY
1–17	(Station/Radar Type) has begun transmission	MFTTIN
18–24	Station No. (x) has begun transmission	MFTTIN
25	Time to fire re-entry table not reach 60,000 ft. This message indicates failure to complete time to fire calculations and the probable absence of a complete set of updated recommended retro times.	MFRARF

TABLE 2-3 ON-LINE MESSAGES (Cont'd)

MESSAGE NO.	MESSAGE	USED BY
26	Sense Switch 2 down, ______________________ in keys	MPDIFC
	If the address of the keys, as specified in the message, contain zero, all differential correction will be bypassed until Sense Switch 2 is reset. If address of the keys contain an internal station number, the differential correction for that station only will be bypassed.	
27	Station No. 27 has begun transmission	MFCPNI
28	Inserted R	MFMAN5
29	Inserted V	MFMAN5
30	Inserted time in hrs. min. secs.	MFMAN5
31	GMTRC for end of present orbit in hrs. mins. secs.	MFRARF
	This is the computed time to fire retros (GMT) to impact in a specified area for the present orbit.	
32	Manual insertion lift-off in hrs. mins. secs.	MFMAN1
33	Manual insertion accepted, number of retros fired	MFMAN2
34	Manual insertion accepted, clock reading read	MFMAN3
35	Manual insertion rejected, enter the message again	MFMANI
36	Abort table has been generated	MFCPNI
37	Abort table reached 60,000 feet	MFCPNI
38	Re-entry table did not reach 60,000 feet	MFCPNI
39	Number of observations presented to differential correction by edit is	MFLED1
40	Floating point trap	MTFLPT
41	Simulated operation begun	M0SENT
42	Normal operation begun	MTWWVI
43	File project tape on B6 and set up new reel	MYSTLT
44	File project tape on B7 and set up new reel	MYSTLT
45	Differential correction rejected	MFDIFC
	On-line messages (45 and 46) will be followed by a number of lines of print indicating the quality of the data that was used in the Differential Correction. If message number 45 is printed without the following lines of print indicating the quality of the data, this indicates an error condition or insufficient input data.	

TABLE 2–3 ON-LINE MESSAGES (Cont'd)

MESSAGE NO.	MESSAGE	USED BY
46	Differential correction successful	MFDIFC
47	Following number of minutes has passed	MYMINS
48–64	(Station/Radar Tape) has ended transmission	MFTTIN
65–75	Station number (x) has ended transmission	MFTTIN
76	Following station has been deleted from differential correction	MFTTIN
	These messages (76, 77 and 78) are under control of Sense Switch 4 (see Operating Instructions, Section 3) and indicate that a manual modification is being made to the Differential Correction processor (D0DIFC)	
77	Following station has been restored to differential correction	MFTTIN
78	Message block for following station is negative	MFTTIN
79	Abort phase above TOWS has been entered	MFLABT
80	Orbit phase has been entered	MFLORB
81	Error in numerical integration process	MFCPNI
	This message indicates a failure to complete numerical integration and that an error exists in the numerical integration generated table. This situation usually requires the evaluation of the input data.	
82	R and V for requested time not within limits of orbit table	MFRARF
	This message results from an error in the interpolation program.	
83	Redundancy occurred on MSG, auxiliary tape being used	MTMFSK
84	Station characteristics tape read successfully	MYSCRD
85	Numerical integration successfully completed	MFCPNI
86–109	(Station/Radar Tape) acquisition data sent	MYTTOX MYTTOY MYTTTOX MYTTTOY
110	A record has been written on the restart tape	MTWRRS MYWRRS MTWRS1
111	Fl.Pt./Oct Rx= Ry= Rx=	MFCPNI MYREST MFLORB MFLABT

TABLE 2-3 ON-LINE MESSAGES (Cont'd)

MESSAGE NO.	MESSAGE	USED BY
112	Anchor time for above R, V values=hrs. mins. secs.	MYREST MFLORB MFLABT MFCPNI
113	R vector accepted, enter velocity	MFMAN5
114	Velocity vector accepted	MFMAN5
115	Flt.Pt./Oct Vx= Vy= Vz=	MYREST MFLORB MFLABT MFCPNI
118	Apogee, nautical miles (in perigee nautical miles)	MFORMC
119	Lat. long. impact point (longitude is degrees West) This message is printed during an abort or re-entry phase only.	MFCPNI
120–143	(Station/Radar Tape) acquisition data not sent	MYTTOX MYTTOY MYTTTOX MYTTTOY
146	Launch Rx= Ry= Rz= These messages (146, 147 and 148) will give the components of the vector used in the launch processors in determining the GO–NOGO calculation.	MFLHLD
147	Launch Vx= Vy= Vz=	MFLHLD
148	Time of lift-off Flt. Pt./oct. secs.	MFLHLD
152	Restart program loaded	MYRSYS
153	Restart program requested	MYQSYS
154	New re-entry table generated	MFCPNI
156	Time-to-fire calculations complete, next recovery area is	MFRARF
158	Line two, low buffer check sum error These messages (158 through 161) indicate IP 7090 input line errors.	10HS09
159	Line two, high buffer check sum error	10HS09
160	Line two high buffer telemetry rejected	10HS09
161	Line two low buffer telemetry rejected	10HS09

TABLE 2–3 ON-LINE MESSAGES (Cont'd)

MESSAGE NO.	MESSAGE	USED BY
162	High-speed output transmission rate to Cape exp., 240, actual	MTWWWV
163	High-speed output transmission rate to Cape exp., 40, actual	MTWWWV
164	High-speed output transmission rate to Cape exp., 20, actual	MTWWWV
165	High-speed output transmission rate to Cape exp., 120, actual	MTWWWV
166	Line one low buffer check sum error	IOHSGB
	These messages (166 through 169) indicate B–GE input line errors.	
167	Line one high buffer check sum error	IOHSGB
168	Line one high buffer telemetry rejected	IOHSGB
169	Line one low buffer telemetry rejected	IOHSGB
170	RSYSERR1 no control or EOF rec after EOF. (ETRT2)	MYRSYS
	These messages (170 through 177) indicate that some error has occurred when trying to read the absolute System Tape on tape unit A1.	
171	RSYSERR2, EOF is first rec. read after Rew, spacing files, (ETRT3)	MYRSYS
172	RSYSERR3, data rec. first rec. read after Rew, spacing (ETRT3)	MYRSYS
173	RSYSERR4, MSREXX err ret-decode file control rec. (ETCWD)	MYRSYS
174	RSYSERR6, MSRECC err ret-decode control rec. after Rew, spacing	MYRSYS
175	RSYSERR7, file no. requested not = file read (ETTS1)	MYRSYS
176	RSYSERR8, MSRECC err ret-decode data rec. (ETECC)	MYRSYS
177	RSYSERR9, data record read too small (ETECC)	MYRSYS
178	Low abort phase has been entered	MFLRT1
179	Medium abort phase has been entered	MFLRT2
180–198	Differential correction rejected	MFDIFC
199–217	Differential correction successful	MFDIFC
218	Orbit-re-entry phase change accomplished	MYREST
219	Time of lift-off is (GMT) in hrs. mins. secs.	MFMAN1 MFHS08 MFHSGB MFML6A

TABLE 2–3 ON-LINE MESSAGES (Cont'd)

MESSAGE NO.	MESSAGE	USED BY
220	N=0, Edit Program rejected, differential correction bypassed	MFLEDI
	N is the number of observations correctly received by the station presently transmitting. If N=0, this indicates that a particular set of low-speed data is not being presented to the Differential Correction program for processing.	
221	The WWV time entered is (GMT) in hrs. mins. secs.	MTWWVI
222	Escape rockets fired	MLUPDT
223	Tower separation signal has been received	MLUPDT
224	Abort initiate signal has been received	MLUPDT
225	SECO signal received	MLUPDT
226	Capsule separation signal received	MLUPDT
227	Capsule separation assumed	MLUPDT
228	No good vectors written on the restart tape	MYRRRS
229–232	No posigrade rockets fired	MLUPDT
233–243	Points used to calculate final GO, NO-GO	MLUPDT
244	GO is recommended	MLUPDT
245	NO-GO is recommended	MLUPDT
246	Insufficient data to recommend GO, NO-GO	MLUPDT
	This message is always printed when there is no B–GE or Azusa data available for the GO, NO-GO computations.	
247	Time of retro-fire is (GMT) in hrs. mins. secs.	MFLHLD
	time of retro-fire for abort situations. time of retro-fire for abort situations.	
248	Velocity used in final GO, NO-GO is (feet per sec.)	MFLHLD
249	Gamma used in final GO, NO-GO (degrees)	MFLHLD
250	Neither Restart Tape can be Error corrected	MYRRRS MYSRST
251	An erroneous trap occurred on the DCC, sub-channel number	MTERTC
252	Orbit table reached 60,000 ft. at hrs. mins. secs.	MFCPNI
	The time printed in hours, minutes and seconds correspond to the last entry in the orbit table and does not necessarily mean that the orbit table has reached 60,000 ft.	

TABLE 2–3 ON-LINE MESSAGES (Cont'd)

MESSAGE NO.	MESSAGE	USED BY
253	Splash* GMT exceeds last time entry in re-entry table	MFABRT
254	Re-entry table generated based on hrs. mins. secs.	MFCPNI
255	Time restarted from is hrs. mins. secs.	MTWWVI
256	Neither restart tape can be read, insert restart values	MYSRST
	The message is printed as a result of restarting the tracking program. This would occur in case of machine malfunction. The restart values that should be inserted via paper tape (see restart operation, Section 3) are the time of lift-off and the R, V and T values at time of insertion.	
257	Manual insertion accepted orbit switch	MFMAOS
258	Manual insertion accepted abort switch	MFMAOS
259	Manual insertion retro-fire time is hrs. mins. secs.	MFMAN2
260	RSYSERA, data record read too large (ETECC)	MYRSYS
	This message indicates that some error has occurred when trying to read the absolute system tape on tape unit A1.	
261	Edit, Differential Correction programs loaded	MYRSYS
262	Edit, Differential Correction programs requested	MYQSYS
263	RSYSMSG, File No. 3 successfully loaded	MYRSYS
264	RSYSMSG, File No. 3 requested	MYRSYS
267	RSYSERR, tape check trap. Machine error if system not enabled	MTRSYS
	This message indicates that some error has occurred when trying to read the absolute system tape on tape unit A1.	
268	Signal to enter orbit phase has been received	
269	RSYSERR, Loc. 10, bits 13–17, illegal config. prob. machine error	MTRSYS
	This message indicates that some error has occurred when trying to read the absolute system tape on tape unit A1.	
270	Station characteristics auxiliary tape cannot be read	MYSCRD
271	Signal to enter abort phase has been received	

* Impact point

Section 3
OPERATING PROCEDURES

This section contains general discussions on the role of both the Goddard and Bermuda complexes prior to, during, and following simulated or real-time operation of the Mercury Program System. The general discussions are followed by detailed procedures designed to aid the operators of both the computing and periphery equipment to perform such manual duties as required during the pre-testing and real-time operation of the Mercury Program System. Figure 3–1 (located at the end of this section) depicts the Goddard operations organization.

3.1 GODDARD OPERATIONS

Pre-mission procedures at Goddard involve last-minute checks of the system and the actual loading of the program into the computers. During the mission, the Computer Operational Director and his staff constantly monitor computer operations and maintain contact with the Mercury Control Center. Following the mission, the Post-flight Reporter program analyses the log tape data. The program decodes the data and collects and arranges it for a more complete analysis at Cape Canaveral and Langley Field.

3.1.1 Pre-Mission Operation

Approximately one week prior to a Mercury mission, the Flight Controllers at Cape Canaveral begin monitoring the testing of the entire program system. These tests are known as "Network Drills." Network Drills accomplish two purposes:

a) To train all personnel in their designated operations and ensure they become familiar with all aspects of the job to be performed.

b) Test the ability of each of the participating sites to perform its designated job in the overall system test.

Network Drills require the integration of each working team at GSFC, starting with the Engineering Test teams and continuing to the Computer System teams; and finally GSFC, by use of its computers, testing the readiness of the various sites to participate in the drill and then entering into support of the network as controlled by the Cape. These tests, besides ensuring that all sites are in a state of readiness, also gives each of the operating groups the necessary experience of cooperation and procedures that are required during an actual mission.

3.1.2 Mission Operation

The Computer Operational Director at Goddard is responsible for mission support operations in the computer room. A Chief Operator is responsible for the loading of tapes to the A and B computers. Two Program Monitors, briefed on the expected (nominal) sequence of events and on-line messages, observe the on-line messages and they also monitor the plotboards. The Cape Coordinator is also directly involved with computer operations; he is responsible for communicating with Flight Controllers at Cape Canaveral and coordinating Goddard activities with the Cape during a countdown. The Cape Coordinator also mans the Output Status Console during countdown and mission periods.

3.1.3 Post-Mission Operation

Immediately after the mission, the log tape is saved and high-speed input and output are dumped. Postflight analysis (see the Postflight Report Program manual, MC–110) prepares a summary of pertinent information recorded on the log tape. The program is capable of reporting for any phase and for any number of log tapes. The log tape is decoded, and the applicable information from it is gathered, arranged and recorded on magnetic tape. This information is sent to Cape Canaveral within 24 hours after Goddard is released from real time computing. A more detailed listing of postflight data is delivered to the Space Task Group at Langley Field, Virginia.

3.1.4 Program System Operating Procedures

There are two different modes of operation of the Mercury Program System: simulated (external environment is simulated by the SIC program) and unsimulated (the system operates in the real environment). In the unsimulated mode, a restart feature of the system may be used. Operators' procedures for the three cases are given below.

3.1.4.1 Simulated Operation

In simulated operation, a job tape is prepared just prior to the execution of a simulated test. The first operation then is MERGE. To reduce the "set-up" time required to prepare for each job separately (MERGE and simulated test) the following operational requirements will serve jointly for both:

a) Prepare and ready the following tape units:

A1—SOS System Tape

A2—Blank (off-line print out)

A3—Blank (job tape)

A5—Modifications (off-line input)

A6—Message Tape

A7—Station Characteristics (A8 is the alternate) (see j)

B1—Blank (used for dump)

B2—Blank (intermediate)

B4—Blank (intermediate)

B5—Blank (intermediate)

B6—Blank (log)

B8—Master Squoze

C1—Blank (off-line print out) optional

C10—SIC Tape (Simulated Input Control Program)

All tapes are low density (except C 10 may be high or low)

b) DCC simulate switch on (up)

c) No sense switches used

d) On depression of the Load Tape button, the first operation, MERGE begins. Watch on-line printer for instructions. When computer stops and the word PAUSE is shown on printer, the operation MERGE is complete.

e) After MERGE replace tape B8 with a blank tape and reset tape unit to B9.

f) Depress START button—Simulation begins. Program will stop in 70,000 area.

g) Enter the following information in the console keys:

1) Starting time in octal seconds, in keys 21–35.

Starting time is time after lift-off you wish the simulation test to begin.

2) Running time in key 3–17.

Running time is desired length of time you wish the program to run.

h) Depress START button twice.

i) If a Memory Dump is desired:

1) For deletion dump—depress key 1

2) For complete dump—depress key 1 and 35 or transfer to 77777.

j) If station characteristics tape (A7) is in error or cannot be read, program will automatically shift to the alternate tape (A8).

3.1.4.2 Operational Program Procedures

a) Normal Operations

Prepare and ready the following tape units:

A1—Absolute system tape (A4 is alternate)

A5—Message tape (A6 is alternate)

A7—Station characteristics tape (A8 is alternate)

B6—Blank (I/O log tape)

B7—Blank (Alternate I/O log tape)

B9—Blank (Restart tape—same as C9)

C9—Blank (Restart tape—same as B9)

All tapes are set to low density.

The sense switch settings shown below are under the direction of the Computer Operational Director.

(All switches in the UP position have no effect).

Sw 1 Down Suppresses logging on B6 I/O log tape.

Sw 2 Down By-passes Differential Correction Program.

Sw 3 Down Enables program to accept paper tape manual insertion data. (See Table 3–2).

Sw 4 Down Deletes or restore station observations.

To delete a station's observations, enter, in keys 21–35, the internal station number of the station to be deleted and depress sense switch 4.

To restore a station's observations, enter, in keys 6–17, the internal station number of the station to be restored and depress sense switch 4. (See Table 3–1 for tracking stations and numbers.)

Sw 5 Down No effect.

Sw 6 Down After GMT has been entered, adds the time of lift-off (GMT) to the time on paper tape messages inserted manually in the ASR's.

IBM 7090 Console Operation:

1) Depress clear and load tape buttons.

2) At command trap (on channels A, B, and C) enter Greenwich Mean Time in decrement (keys 6–17). Time is entered in octal hours and minutes.

3) Depress the sign key no later than 10 seconds before the time that was entered in decrement (keys 6–17). The sign key causes the program to accept the time and computer is now in synchronism with GMT. The time is printed on the on-line printer. If the wrong GMT is entered—clear and reload.

4) After GMT has been accepted, the program comes to a program stop.

5) At the command of test director ("start cycling") depress START key. The program is now in execution.

6) During execution, depression of the following keys displays the output transmission of the plotboards on the local displays.

   Key 20—Plotboard 1

   Key 19—Plotboard 2

   Key 19 and 20—Plotboard 3

   Key 18—Plotboard 4

To obtain a Memory Dump:

1) Stop program by putting computer in manual.

2) Prepare and ready the following tape units:

   A2—Blank—used for dump (Output)

   B1—Blank—used for dump (Intermediate)

   B2—Blank—used for dump (Intermediate)

   B4—SOS Memory Dump Tape

   B5—Blank—used for dump (Intermediate)

3) Set computer to automatic (manual/automatic button) and depress START key.

4) Depress keys for memory dump

   Key 1—Deletion dump

   Keys 1 and 35—Complete memory dump

5) Program sorts and "core out" on B tape units and come to a stop.

6) Replace A1—Absolute system tape with SOS system tape.

7) Depress START button—write the output of core on A2.

If for any reason A1, A5, or A7 cannot be read during execution time, the program automatically shifts to the alternate tape. If B6 I/O log tape becomes full, output shifts to B7. If the computer stops for any reason:

1) Write end of files on B6, B9, and C9.

2) Log and label B6 appropriately.

TABLE 3-1 TRACKING SITES INTERNAL AND EXTERNAL STATION NUMBERS

	STATION NAME	EQUIPMENT AT SITE*	EXTERNAL STATION NUMBER	INTERNAL STATION NUMBER**
1.	Cape Canaveral	F	31	1
		T	31	—
2.	Grand Bahama	F	41	2
		T	41	—
3.	Grand Turk	T	51	20
4.	San Salvador	F	61	3
		T	61	—
5.	Bermuda	F	02	4
		V	02	5
		T	02	—
6.	Mid Atlantic Ship	T	03	21
7.	Grand Canary Island	V	04	6
		T	04	—
8.	Kano	T	05	22

TABLE 3–1 TRACKING SITES INTERNAL AND EXTERNAL STATION NUMBERS (Continued)

STATION NAME	EQUIPMENT AT SITE*	EXTERNAL STATION NUMBER	INTERNAL STATION NUMBER**
9. Zanzibar	T	06	23
10. Indian Ocean Ship	T	07	24
11. Mucheo, Australia	V	08	7
	T	08	—
12. Woomera, Australia	F	09	8
	T	09	—
13. Canton Island	T	11	25
14. Hawaii	F	12	9
	V	12	10
	T	12	—
15. Point Arguello, Calif.	F	13	11
	V	13	12
	T	13	—
16. Guaymas, Mexico	V	14	13
	T	14	—
17. White Sands, N. M.	F	15	14
18. Corpus Christi, Texas	V	16	15
	T	16	—
19. Eglin Field, Florida	F	17	16
	V	17	17
20. Bermuda 709	F	81	18
	V	81	19

* Equipment located at each sight is indicated in the following manner:

T — Telemetry Receiver
F — AN/FPS-16 Radar
V — Verlort Radar

** No internal station number is assigned to a telemetry receiver when there is a radar located at that particular site. The station characteristics block is set up in reference to the Internal Station Numbers.

b) Restart Operations

The computer "set-up" (program, tapes, etc.) in restart is the same as in a) Normal Operations. Because of the different methods of restarting and the various number of times and conditions under which restart could occur, a brief discussion on the restart procedure follows.

Restart consists mainly of two types: 1) those cases in which core memory is destroyed (computer malfunction or unrecoverable errors) and 2) those cases in which core memory is not destroyed but incorrect input data caused the program to malfunction. In the latter case, it is only necessary to punch paper tapes with the desired R and V vector and insert into the system. This is accomplished by depressing sense switch 3 to accept manual insertion and manually entering the R and V vector tapes three times. (See operation ASR Subsection 3.1.4.4 and paper tape format —Table 3-2).

The former case, however, is a bit more complicated. Whenever a "clear-the-machine restart" is desired, key 1 (not 35) should be placed in the down position so that the program transfers to MOENDS. MOENDS writes an end-of-file on the restart tapes after which a dump of the program is automatically taken. If it is impossible to transfer control to MOENDS, an end-of-file should be manually written on the restart tapes (B9 and C9) from the console. The log tapes (B6 and B7) should be unloaded, labeled, and replaced by blanks. The absolute system tape A1 should be rewound, followed by a clear and load tape. When the program reaches the stop at which Time is entered, (command trap on channels A, B, and C) the desired restart time should be placed right-justified in keys 18–35 in octal hours, minutes, seconds; the present Greenwich Mean Time should be placed right-justified in keys 6–17 in octal hours and minutes; and the orbit number should be placed right-justified in Keys 2–5 in octal. The S-entry key is then depressed to accept the time. For example, the Greenwich Mean Time on the next minute is 15 hours 30 minutes, the desired restart time is 12 hours 15 minutes 45 seconds, and the orbit number 3. The following key configuration should then be used:

S–1–2	3–5	6–8	9–11	12–14	15–17	18–20	21–23	24–26	27–29	30–32	33–35
S	3	1	7	3	6	1	4	1	7	5	5
Indication to accept time entered	pass No.	octal hrs.		octal mins.		octal hrs		octal mins.		octal secs.	
		Greenwich Mean Time				Restart Time					

The critical factor is determining the proper restart time. Whenever a differential correction is accepted or rejected (there may be more than one differential correction for a station), an on-line message with the associated time in hours, minutes, and seconds is printed. When the final differential correction has been computed for a station, its values are written on the restart tape, and also indicated by an on-line message. Thus, if it is desired to restart the system, the time used should be the time associated with the message which indicates that differential correction was accepted or rejected.

If the chosen differential correction is final for the station and if the values have been written on the restart tape, the system is restored to its previous status at the time of the differential correction. If, however, the differential correction is not final for the station or if the values have not yet been written on the restart tape, the system is restored to its status at the time of a previous differential correction, i.e., the final differential correction for the preceding station.

When the contents of the computer have been restored, any manual input entered prior to the time of the selected differential correction is remembered, whereas any time entered afterward must be re-inserted. For example, if the selected differential correction was computed during the re-entry phase, the program enters the re-entry phase automatically. However, if the fact that retrorockets have fired and the time of firing has been manually inserted, the program shifts to the re-entry phase. If the selected differential correction occurred during the orbit phase, the program is initialized and manual input must be re-inserted so that the computers switch to re-entry processing.

If the situation is such that neither restart tape has been properly written, an on-line message is printed indicating that neither restart tape can be error corrected. The only recourse in such a case is to restart from insertion by manually inserting to the computers the GMT of lift-off and the insertion R and V. (Sense switch 3 must be down. GMT of lift-off must be entered once, the R vector must be entered 3 times, followed by the V vector 3 times.)

Another condition which may arise is that neither restart tape has been written, in which case a message is printed on-line indicating that neither restart tape can be read. In this event either the program must be re-run using a later restart time or the system is initialized to begin at the time of insertion in the manner described in the preceding paragraph. Note that should the computer malfunction during launch, the above procedure would have to be employed, since the system cannot be restarted in launch. However, given a time of lift-off and an insertion R and V, the system can be restarted from insertion. Restart is effective only at the time of insertion into orbit, during orbit or in re-entry only if re-entry is entered from orbit.

3.1.4.3 Logging Programs

Upon completion of an operational run, either simulated or unsimulated, the log tape (s) produced are interpreted by the routines HSIN5, MXHSPR, and MXPRLG.

Operators procedures for these routines are given below:

a) HSIN5 (decode high-speed input)

Prepare and ready the following tapes:

A3—Blank—BCD output tape

B6—Log tape

Place deck in card reader

Clear and load cards

At program stop, set address of keys as follows:

Key 1—B/GE data selected

Key 2—IP 7090 data selected

Key 3—Raw radar data in radians

Key 4—Raw radar data in degrees

Key 5—End job

Depress START key

At end of job write end of file on tape A3, rewind and have printed

b) MXHSPR (decode high-speed output)

Prepare and ready the following tapes:

A5—Output tape

B6—Log tape

C6—Intermediate tape (high density if possible)

Place deck in card reader

Depress clear and load card button

Job finishes with the on-line printing of the following message:

JOB COMPLETE—PRESS START FOR COMPLETION.

Pressing the START button at this point writes 4 end of files on tape A5, rewinds and unloads all tapes used. If more than one log tape is to be processed, their outputs can be batched by clearing the machine after the end of job message is printed, writing an end of file on tape A5, and reloading the program with the new log tape on B6.

c) MXPRLG (decode low-speed output)

Prepare and ready the following tapes:

B6—B6 Log tape as input

A2—Blank

No sense switches used

Place deck in card reader

Depress clear and load cards

When program stops, set the keys corresponding to sub-channels desired, i.e., keys 14 thru 30 for channels 14 thru 30. Sense lights indicated the number of channels to be processed.

Depress START key

Final halt:

Halt 10536 Write end of file on tape A2

Print program control

Program does not rewind tape A2

3.1.4.4 Special Equipment

The Goddard computer operators must, in addition to the 7090's and the DCC's be familiar with the operation of the following equipment:

a) Milgo Electronic Corporation, Tape Recorder, Model 1585—used for the transmission of high-speed data into the Mercury Program System (see Figure 3–2).

FIGURE 3–2. SPECIAL EQUIPMENT

b) American Telephone and Telegraph Company, Automatic Send/Receive Unit—used for manually inserting teletype data into the Mercury Program System (see Figure 3–2).

The operation of the Model 1585 Tape Recorder (see ME–918 manual, p. 1) is discussed below:

a) Place desired tape on lower hub and lock reel on by turning wings in a counterclockwise direction.

b) Thread tape as shown by the diagram on the recorder.

c) Operation of push buttons on 1585 recorder:

1) Power Push Button—Depress power push button—power is applied to the recorder and a light will lite which indicates either high speed or low speed. Depressing the power push button again will shut off power and extinguish all lights.

2) Low Speed Push Button—All recordings to date have been recorded at low speed. Depress low speed push button if high-speed light is on. The high-speed light will go out and the low-speed light will come on. The recorder is now in low speed.

3) Rewind Push Button—Depress the rewind push button and tape will move from the upper reel to the lower reel at high speed. When the desired section of the tape has been reached, depress the stop push button.

4) Fast Forward Push Button—Depress the fast forward push button and tape will move from the lower reel to the upper reel at high speed. When the desired section of the tape has been reached, depress the stop push button.

5) Drive Push Button—Depress the drive push button and tape will move from the lower reel to the upper reel at low speed. This condition is used for play back of recorded tapes. When playback is completed, depress the stop push button.

6) Record Push Button—Depressing the record push button starts the recording process. Do not depress this push button. At present a Kingston Engineer will be present when a recording is to be made.

d) Select the record on the tape that is desired. This may be done by the use of the fast forward rewind or drive push buttons to move the tape to the desired record.

e) On the receiver, make sure that the operate test switches on both the IP 7090 and B–GE receivers are in the Operate position.

f) On the transmitter, make sure that the operate test switch is in the Operate position.

g) On the transmitter, set the recorder operation switch in the desired position.

   1) Transmit—Output of the tape recorder is sent to the transmitter for transmission to the Cape via the high-speed phone lines.

   2) IP 7090—Output of the tape recorder is sent to the input of the IP 7090 receiver and is processed by that receiver.

   3) B–GE—Output of the tape recorder is sent to the input of the B–GE receiver and is processed by that receiver.

   4) IP–B–GE—Output of the tape recorder is sent to the inputs of both the IP 7090 and B–GE receiver and is processed by both receivers.

   5) Recorder operation switch should always be left in the Operate position until playback facilities are required.

h) When playback is requested, depress the drive push button. When playback is completed, depress the stop push button.

The operation of American Telephone and Telepgraph Company, Automatic Send/Receive Unit (see MS–108 manual, p. 98, Figure 3–3, and p. 100) is discussed below:

a) Set line/test switch to line position.

b) Set K–KT–T switch to KT.

c) Set switch on tape feed unit to FREE.

d) Push button on top of feed unit to raise clamp.

e) Place 5-hole punched tape on feed unit making sure that sprocket engages feed holes and that two of the 5 channels lie to the rear of the sprocket and 3 toward the front.

f) Clamp the tape in position.

g) Set switch on tape feed unit to RUN. (The input message at this point enters the system.)

h) To stop operation, set switch on feed unit to STOP.

i) To remove tape, push button on top of feed unit to raise clamp.

Table 3–2 gives the format of the manual override paper tape messages that are entered in the ASR's at Goddard. Each of the following message formats must be preceded by at least 6 figures shifts (↑) and followed by at least 15 letter shifts (↓).

TABLE 3–2 MANUAL OVERRIDE MESSAGE FORMAT

MESSAGE	FORMAT
Abort switch	/222/ ABORT / ABORT / ABORT /
Orbit switch	/333/ ORBIT / ORBIT / ORBIT /
Greenwich Mean Time of Lift-off (GMTLO)	/444/hh mm ss/hh mm ss/hh mm ss/ (hh mm ss = Hours, Minutes, Seconds)
R vector	/555/hh mm ss / X / Y / Z / (X, Y, and Z are a signed 12 character floating point octal number.) (For the R and V vector messages, the time must be in hours and minutes only, with seconds punched zero.)
V vector	/777/hh mm ss / X / Y / Z / (X, Y, and Z are a signed 12 character floating point octal number.)
Retrofire	/888/N N N / hh mm ss / hh mm ss / (N is the number of retros fired.)

The preparation of the paper tape station observation messages that are entered manually through the ASR's is discussed in Simulation Programs manual, MC–108. (The Simulation Program, Shred prepares a magnetic tape which is used for a tape-to-tape operation.)

3.2 BERMUDA OPERATIONS

Immediately preceding an actual mission, testing at Bermuda in addition to that described in Section 2 is necessary to ensure that the program system is working as it should. This final checkout, however, is only part of the set of steps needed to maintain effective and accurate computation and control. The operating procedures which must be followed to support a mission are numerous and complex. The following paragraphs describe in general these procedures which take place at Bermuda before, during and after a Mercury flight.

3.2.1 Pre-Mission Operation

At least one week before a mission, Flight Controllers begin continuously testing the operation of the entire Mercury Bermuda programming system. The extensive testing undertaken during this period aids in training the Flight Controllers, in addition to accomplishing its purpose of locating discrepancies in the system.

Tests are made from the Absolute System tape to ensure that it is written correctly; using the B-Simulator, the tape is checked with available data to determine whether the computed output quantities are consistent with radar data input. The absolute tape does not provide a core dump, but high-speed input and output information can be dumped (phase outputs are checked from the latter).

At the same time (one week prior to mission) that the System tape is generated, a duplicate, or A3, tape is prepared. The A3 tape can be used to check the absolute tape; it can be cored out and used in debugging to check for expected error codes and internal consistency.

The day before a mission the entire programming system is re-checked (see Bermuda Countdown, Subsection 4.2). At this time the Station Characteristics tape is updated and checked, based on estimated meterological conditions such as refraction correction, and the longitude of the launch pad for midnight preceding launch. If possible, this is the same tape used for actual launch computations.

Countdown procedures established on the day previous to launch are duplicated on the date of launch. The Operational Program Director, two IBM 709 computer operators, a Special Service Engineer (for Milgo equipment) and the Customer Engineer (for the IBM 709 and DCC) are the only personnel in the computer room. The Operational Program Director is responsible for all programming and related activities in the computer room (see Figure 3–3).

Ten hours before launch the 709 complex is readied for operation by the Customer Engineer. The operational program is loaded and cycled for two WWV traps four hours later; Milgo equipment is prepared for operation 5-3/4 hours prior to launch. If necessary, the Station Characteristics tape is again updated.

Final checks are made and the computer room is cleared of personnel other than those mentioned above three hours before launch. The Mercury Program System is loaded and cycled, and the Output Status Console is monitored through a simulated trajectory exercise one hour prior to launch. Thirty minutes later the system is again loaded, cycled and ready for an indication of launch vehicle lift-off.

3.2.2 Mission Operation

Mercury Program System operation after launch is supervised primarily by the Operational Program Director, who acts as a monitor. He reports the actual receipt of events to, and maintains constant contact with, the Flight Dynamics Officer regarding operational status and phase (phase is indicated on the Flight Dynamics Officer's Console and Output Status Console, and can be inferred from events printed on-line). After launch the only other procedure used is the reloading of the program for succeeding passes.

Information regarding unexpected events is immediately communicated to the Flight Dynamics Officer and the Maintenance and Operations Chief by the Opera-

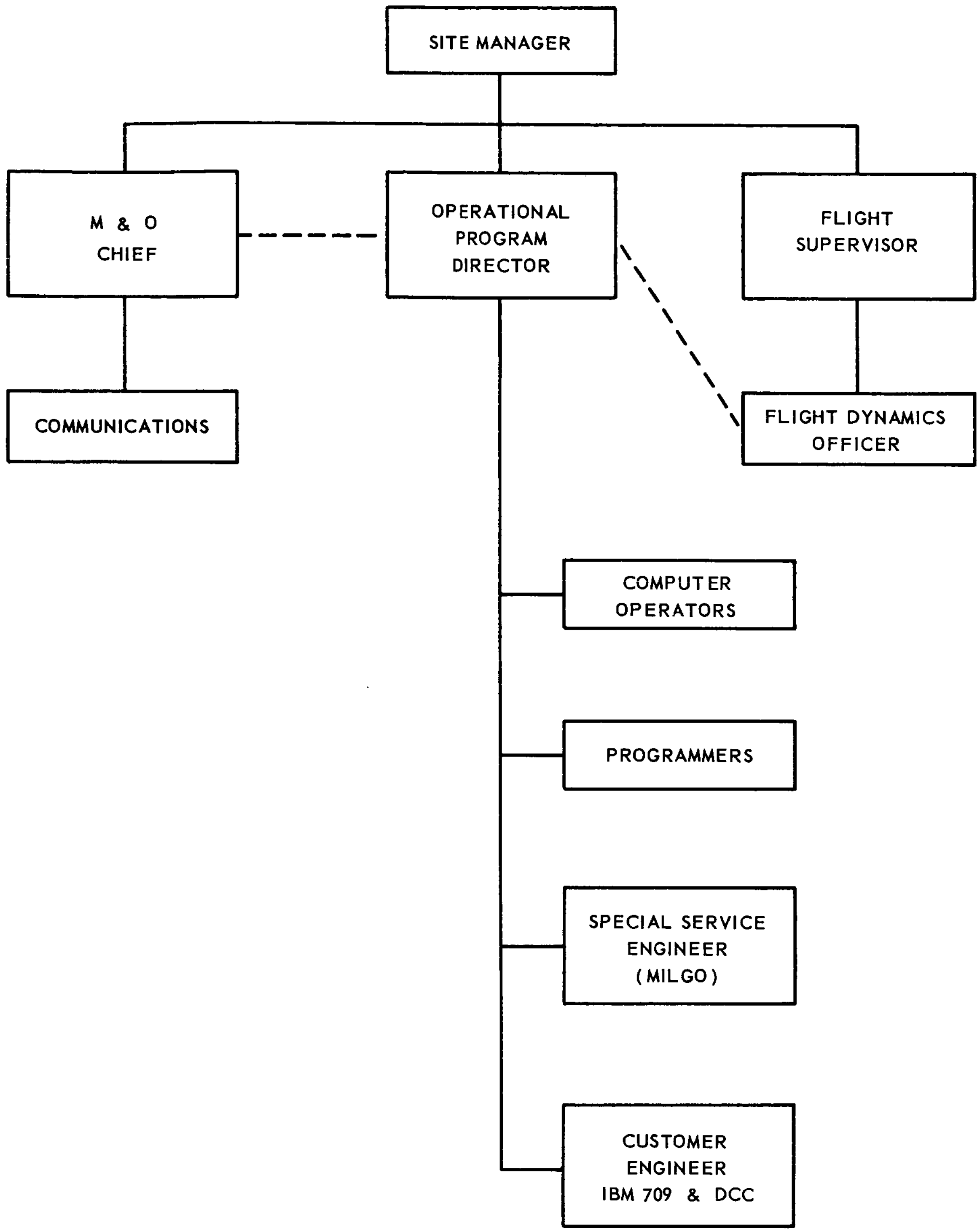

FIGURE 3-3. BERMUDA MERCURY OPERATIONS ORGANIZATION

tional Program Director. Some of the precautions taken to prevent the occurrence of unexpected events are:

a) Message and System tapes are duplicated.

b) Log tapes to standby status.

c) All other tapes to backup status.

3.2.3 Postmission Operation

Bermuda's postmission activities are not as complex as those at Goddard. The station makes no contribution to the Postflight Reporter program, but the log tape is saved and high-speed input and output are dumped. Two programs extract the input and output, and two programs and a subroutine, taken in combination, create a log tape of radar data from either the DCC or an SIC tape and print this information on-line or off-line.

3.2.3.1 High-Speed Input Program

The High-Speed Input program searches the log tape for high-speed input messages; these messages have a 1 in the decrement of the first word in the heading prepared by the Monitor logging subroutine, MSLOGG. Time, range, azimuth and elevation are printed for each radar—time is in tenths of seconds, range is in feet, and azimuth and elevation are in ten-thousandths of radians. The second and third words of the heading are also printed. These words contain, respectively, the time the message was sent to the computer and the time is was logged.

3.2.3.2 High-Speed Output Program

The High-Speed Output program searches the log tape for high-speed output messages, each of which contains a 2 in the decrement of the first word in the heading prepared by MSLOGG. The following quantities are printed for each message: the time of output and the time logged, in tenths of seconds; phase and frame; the four plotboard quantities, in octal; and the values from the Flight Dynamics Officer's Console (these values depend upon the phase and frame). The phase is determined from the prefix of the fifth word of the heading.

3.2.4 Program System Operating Procedures

Certain manual operations must be performed at Bermuda prior to, during, and following a simulated or real-time Mercury mission. The following pages contain a step-by-step account of these operations.

3.2.4.1 System Tape Preparation

The System tape is one of the first checkpoints in premission procedures. Steps in its preparation are listed on the following page.

a) Mount the following tapes:

A1 SOS System tape

A2 Blank

A3 Blank

A6 Blank—dialed off after primary tape is completed

A* Blank—dialed on A6 for preparation of auxiliary tape

B1 Blank

B2 Blank

B8 Master squoze tape

b) Enter modifications:

1) Place Monitor test deck in card reader (NOTE: Card ALTER 776, 776 must be removed.)

2) Depress sign key on the console.

3) Press CLEAR and LOAD CARDS.

4) Program halts, after merge, at 7736_8.

5) Reset sign key and press START.

6) Program halts at 11056_8.

c) Write primary System tape on A6:

1) Message printed on-line: PUT BLANK ON A6 AND PRESS START

2) Press START to write primary System tape on A6.

3) Program halts at 10636_8.

4) Message printed on-line: SYSTEM TAPE SUCCESSFULLY WRITTEN

5) Dial off A6 and label "Absolute System Primary."

d) Write auxiliary System tape:

1) Dial new blank to A6.

2) Press START.

3) Program halts at 10636_8.

4) Mesage printed on-line: SYSTEM TAPE SUCCESSFULLY WRITTEN

5) Dial off A6 and label "Absolute System Auxiliary."

3.2.4.2 B-Simulator Operating Instructions

The B-Simulator is used as a testing device to check computed output quantities against radar data inputs. The operating instructions presented below follow checks to ensure that all input/output devices (high-speed input, high-speed output, telemetry and Output Status Console) have been turned on.

a) Mount the following tapes:

A1 SOS System tape

A2 Blank BCD output

A3 Blank—Job tape

A6 Message tape

A7 Station Characteristics tape

B1 Blank

B2 Blank

B6 Blank log tape

B8 Master squoze tape

b) Place MXMRGE and ALTER decks in card reader.

c) Depress sign key.

d) Press CLEAR and LOAD CARDS.

e) When cards are read in, stop occurs. Press START.

f) Raise sign key when A3 has been merged and A1 starts to move.

g) Program stops at 10742_8. Press START.

h) Program halts at 15422_8.

i) Insert GMT (octal in keys—hours in decrement, minutes in address. Sign key must be depressed within 60 seconds before time is set in keys.

j) Depress sense switch 6.

k) Elapsed ground time clock must be started on a full minute, when required.

l) Start B-Simulator tape at beginning of data.

m) To start processing data, press START. Data will be accepted.

n) Turn on "Capsule Separate" switch at four minutes and 54 seconds after launch (one minute and 29 seconds after starting B-Simulator tape). This switch may be either in the control room or the telemetry even buffer box. (NOTE: This procedure need NOT be followed if signal is on telemetry section of tape.)

o) Turn on ICTRC switch at two minutes and six seconds after starting B-Simulator tape.

p) Turn on retrofire switches in sequence at five-second intervals at two minutes and 30 seconds after starting B-Simulator tape. (NOTE: This procedure need NOT be followed if signal is on telemetry section of tape.)

q) To stop B-Simulator run:

   1) Push RESET button.

   2) Transfer to 77777_8. Deletion dump starts.

   3) Press START when stop at 10677_8 occurs.

   4) Final stop is at 1402_8.

3.2.4.3 Operational Program

The procedures in this subsection are followed each time the program is to be loaded and cycled. However, the countdown shows that the Mercury Program System is loaded for the last time before lift-off at T-00:30—30 minutes before lift-off. (The following actions take place, for this discussion only, beginning at T-00:30.)

On-Line Printer: The paper supply and the condition of the print ribbon are checked. Events as indicated by the program are monitored.

Data Communication Channel (DCC): The DCC simulate switch is turned off (up).

Absolute Program:

a) Mount the following tapes:

A1 Absolute System Primary tape

A4 Absolute System Auxiliary tape

A6 Bermuda Message tape

A7 Bermuda Station Characteristics tape

B6 Blank (log tape)

b) Press CLEAR and LOAD TAPE

c) Program stops at approximately 14526_8 (an HTR *+1). WWV is enabled and trapping every minute.

d) Enter GMT (octal) in keys—hours in decrement, minutes in address. Depress sign key. Time is entered at next WWV trap and the Station Characteristics tape is read.

e) The program idles, keeping track of time (THE FOLLOWING NUMBER OF MINUTES HAS PASSED).

f) Press START to begin input of data (from here the program runs for 32 minutes—it runs no longer because of a table limitation in the Seven Point Smoothing program, BS07PT).

g) To halt, press CLEAR button. There is no procedure at present for core dump.

It is unnecessary to continue running the program when the capsule is out of tracking range, since Bermuda functions only as a tracking station after the launch phase. The program is reloaded for each successive pass (two passes after launch in a three-orbit mission—nominal re-entry is out of Bermuda's tracking range).

3.2.4.4 Logging Programs

The input and output of the three logging programs used at Bermuda together with their operating procedures is presented below.

NAME OF PROGRAM	INPUT	OUTPUT
Roman Numerals (optional)	DCC data B6 (log tape)	B6 (log tape) Printer
Greek Numerals (optional)	SIC tape B6 (log tape)	B6 (log tape) A2 (BCD output tape)
Greek Letters	B6 (log tape)	A2 (BCD) output tape)

The Roman Numerals program is run on the Ampex recorder for a more thorough analysis of input. It is used for equipment testing and to create the B6, or log, tape from each new B-Simulator tape received in Bermuda. The Greek Numerals program prepares a listing of every SIC input tape received by or generated at Bermuda. The subroutine, Greek Letters, is used with the Roman Numerals program to prepare for the off-line listing of data on the B-Simulator tapes and for off-line listing of the results of any other tests which require documenting.

Operating Procedures for Roman Numerals Program:

a) Mount the following tapes:

A1 Blank—program loads from tape after first card is loaded.

A6 Blank

b) Starting Procedure:

1) Ready the card reader and set deck.

2) Press CLEAR and LOAD CARDS.

3) Program halts after cards have been read.

4) Set sense switches desired:

SS–1—down—log Verlort and AN/FPS–16 data

SS–2—down—print AN/FPS–16 data

SS–3—down—print Verlort data

SS–4—up and

SS–5—down—print range only

SS–6—down—print azimuth only

SS–5 and SS–6—down—print elevation only

Printout is in gray binary (a radar code), binary, decimal or octal.

SS–4—down—and

SS–5—down—print binary

SS–6—down—print octal

SS–5 and SS–6—down—print gray binary

SS–4—down—print decimal

Any combination produces a printout of range, azimuth and elevation in the form selected.

5) Depress keys 18 and 19.

6) Press START.

c) Stopping Procedure:

1) Raise SS–1 to stop logging.

2) Raise SS–2 and SS–3 to stop printing.

d) Sequence Printing:

1) Keys 20–35 are used to enter the sequence number from which printing is to begin. The number is entered by using four keys for each decimal digit. For example, print from sequence 59:

Keys 29 and 31—down=5

Keys 32 and 35—down=9

2) After the sequence number is entered, press down SS–2 or SS–3. Tape B6 rewinds and searches for the proper sequence number, printing continues until stopped manually or until an end-of-file is reached.

e) Printing Differences—Keys 1–7 are used for this operation with the procedures used under d, above. The difference selected is entered into the keys in octal form by using three keys for each octal digit. The maximum difference is 377777_8. A second difference is printed which is greater than or the same as that entered in the keys.

f) The program writes an end-of-file (EOF) on B6 and halts when no more data is being logged. To continue, press START and use necessary switches.

Operating Procedures for Greek Letters Subroutine:

a) Mount the following tapes:

A2 Blank

B6 Roman Numerals log tape

b) Program deck is self-loading.

c) Program Stops:

HPR 1 Program is loaded; set switches and start.

HPR 2 EOF is on B6.

d) Sense Switches—The settings are identical to Roman Numerals, with one exception:

SS–1—up—no one-line printing.

SS–1—down—on-line printing of data written on A2.

e) Entry keys are used in the same manner as for Roman Numerals.

f) Restriction—This subroutine does not log; no EOF is ever written on A2.

3.3 PERSONNEL DUTIES

As noted in the foregoing description of Mission Operations, many functions must be performed and coordinated to implement and support the computer operations. A summary of the overall duties of personnel directly involved in the testing and operation of the Mercury Program System is presented below. Figure 3–1 depicts the operations organization.

3.3.1 Computer Operation Director

The tentative duties of the Computer Operations Director are:

a) to make necessary arrangements for computer time to perform all operations

b) to assist in the preparation and distribute to all groups a detailed countdown procedure

c) to inform all groups of their allotted machine time

d) to coordinate the testing periods required for communication/computer operation

e) to inform Time Standards of critical time periods

f) to clear with AT&T the requirements for High Speed Data lines

g) to make necessary arrangements that voice communication is adequate

h) to make arrangements that security exists when necessary

i) to provide adequate working facilities or space for each team

j) to relay to each team any change of status in network

k) to report to Goddard Site Director and Network any change in status of operations at GSFC

l) to decide necessary action to be taken in case of change of procedures

m) to collect from GSFC, CNV & BDA such printouts and tapes, etc. which will form a "live launch library" from which analysis and recreation of live runs can be made

n) to act as liaison between Network Control group and GSFC for scheduling requirements.

3.3.2 CADFISS Test Director

The tentative duties of the CADFISS test director are:

a) to secure from Operations Director a detailed countdown procedure

b) to contact and remain in voice communication with the Flight Director at the Cape

c) to insure that each team performs its designated task at the appointed time as described in the countdown procedures

d) to report to the Operations Director the results of all required functions

e) to provide coordination between the Cape and GSFC for each task performed

f) to relay to the Operations Directors any change in procedures as required by the Cape or at GSFC

g) to reconfirm the extent to which all Mercury sites will be able to participate in exercises

h) to keep a written record of all operations as performed and the results of these tests.

i) to have absolute control of operations in the computer area when acting as Test Director

j) to keep the Flight Director at the Cape informed as to progress of mission as determined at GSFC

k) to inform Computer-Communications Coordinator of expected times that TTY communication will occur

l) to monitor Output Status Console and select desired computer in case trouble develops on one.

3.3.3 System Test Director

The duties of the System Test Director is the same as that of the CADFISS Test Director except the times that each is in control of the operation.

The countdown procedures allow the CADFISS Test Director to be in control during the preliminary activities of Sub-system tests and CADFISS Roll Calls; and the System Test Director to be in control during the final stages of countdown when the tracking program is being confirmed and the actual mission occurs.

3.3.4 Message Monitors

The tentative duties of the Message Monitor are:

a) to monitor the computers in their sequence of operation

b) to recognize the series of events that occur and are printed, i.e., "lift-off has occurred"

c) to compare the events with known information to determine if any deficiencies exist

d) to inform the Test Director of the time that events occur, the computers progress, and the expected results.

3.3.5 Computer-Communication Coordinator

The tentative duties of the Computer-Communications Coordinator are:

a) to coordinate activities between the CADFISS and System Test Directors and the communication network

b) to inform Test Directors of status, and subsequently any change in status, of communications network

c) to relay to communications any change in status of computer operations

d) to insure that the TTY message monitors in computer area are ready to handle all traffic

e) to monitor the messages transmitted and received from remote sites, as to completeness of message, correct format, and successful completion

f) to relay both to Computer Test Director and communications any discrepancies in messages

g) to give the Test Directors, any messages referring to status of net, countdown, etc. which prints on the message monitors

3.3.6 Operators

The tentative duties of the Operators are:

a) to insure that an adequate supply of paper, blank tapes and label-on tape is readily available

b) to obtain from files all necessary tapes and programs to perform operation

c) to have available, utility programs and operating notes in case an emergency stop occurs

d) to become familiar with complete operating procedures of all Sub-system tests and operational programs, run during a Mercury operation

e) to monitor operation of computer for possible tape errors, unlisted stops, equipment malfunction, etc.

f) to adequately label all material; paper, plots, tapes, etc. with information relative to operation

g) to prepare a list of all material and give to Test Director for future reference

h) to provide at request of Test Director, provisions for making quick analysis of logged data

i) to have printed, any tapes where operation requires an early print-out

j) to become familiar with operation of Operational Data Recorded and Plotboards.

3.3.7 Engineers

The tentative duties of the Engineers are:

a) to insure reliability of equipment

b) to perform designated tests at appointed times

c) to inform Test Director on status of equipment

d) to provide to Test Director an estimate of repair time if necessary

e) to monitor equipment at request of Test Director

f) to log all pertinent data regarding operation of equipment

g) to monitor high speed lines for proper operation.

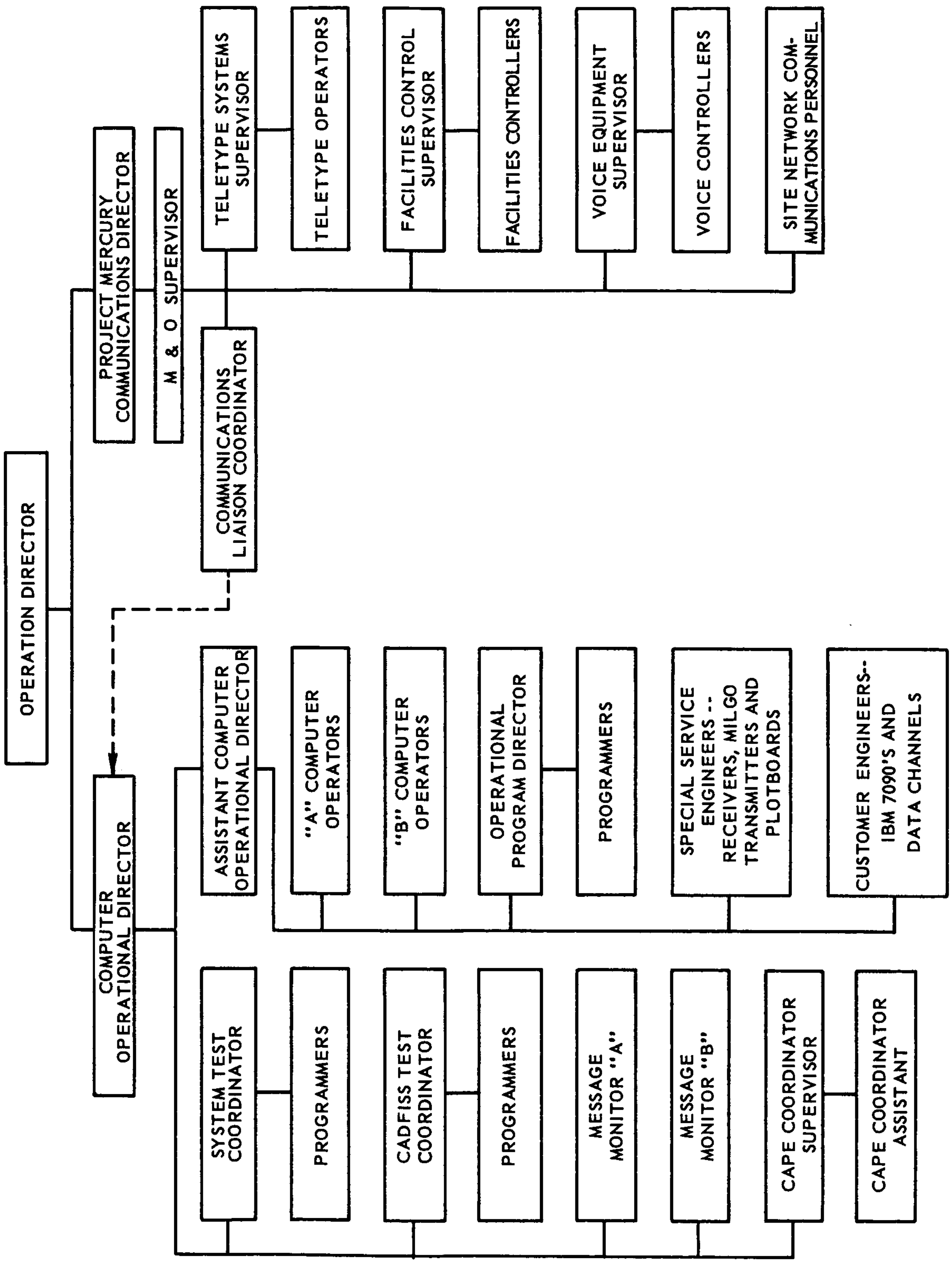

FIGURE 3–1. GODDARD-MERCURY OPERATIONS ORGANIZATION

Section 4
MISSION COUNTDOWN

4.1 GODDARD COUNTDOWN

The function of the Goddard computers and computer-associated equipment is to compute the path of the capsule during all phases of the flight to enable control analyses and decisions to be made concerning the mission. Continued monitoring of the flight is made possible by plotboard and telemetry displays which are driven by the Mercury tracking and computing equipment.

This section deals briefly with the Goddard personnel who operate and maintain the system and includes the MA–4 countdown.

4.1.1 Mission Support Groups

Mission support groups are divided into two categories—those associated with the operational program and the computers, and those concerned with communications and monitoring activities.

4.1.1.1 Programming and Related Groups

These groups operate, test, or maintain the computer and its supplemental equipment. Groups in this category include: Operational Programming Group, Kingston Engineers (Milgo maintenance), Customer Engineers (IBM 7090 and DCC maintenance), and the CADFISS (Computation and Data Flow Integrated Subsystem Group).

Operational Programming Group: This group is responsible for developing and testing the Mercury Program System and for operating the system before, during and after the mission. In addition, this group loads the program into the system, monitors its operation, and performs postflight analysis (see Postflight Reporter Program Manual, MC–110).

Kingston Engineers—Milgo Maintenance: The Kingston Engineers maintain the Milgo equipment—Ampex tape recorders, data transmitters and receivers, and plotboards—and perform detailed equipment checks and participate in CADFISS testing. They are available during countdown and mission periods and are directly responsible to the Computer Operational Director. The following lists in more detail the duties of the Kingston Engineers:

a) The Engineers turn on power to the high-speed equipment and contact Cape Canaveral by phone to test the high-speed lines using sample signals.

b) The data signals are then scoped to insure no lines are open; that amplitude of signal exists, and that all equipment is operating. If trouble is found in the high-speed lines, A. T. & T. is notified by calling the trouble board in Washington, D. C. and also the FAX Controller at Goddard.

c) A diagnostic program high-speed input is entered into the computer and the two high-speed input receivers, the transmitter at the Cape, the data lines, and the associated equipment are checked. The input is compared with a known pattern and results printed on the computer's printer.

If trouble exists, the engineers with the assistance of the computer can compare the input bit for bit. It is compared for bit pick-up or drop-out. The trouble is then diagnosed and repaired.

d) The diagnostic program high speed output is entered into the computer to check the high-speed transmitter at Goddard and the receivers at the Cape. Tests are performed in a similar manner as above.

e) The high-speed output program is also used to operate the displays at the Cape and perform tests on the X-Y recorders (plotboards) at Goddard. This is necessary for calibration of the recorders.

Customer Engineers: These engineers maintain the Goddard complex which consists of the following equipment:

a) Two IBM 7090 computers including associated tape drives, card readers, printers, and card puncher.

b) Two Data Communications Channels and associated circuitry.

To accomplish their tasks, the Customer Engineers use the following to check the operation of this equipment.

a) 7090 Diagnostic Program 9S51—Memory Check

b) 7090 Diagnostic Program 9M51—Main Frame Check

c) 7090 Diagnostic Program 9C51—Card Reader Check

d) DCC Diagnostic Program—One Minute Clock Check

e) DCC Diagnostic Program—60-Cycle Clock Check

f) DCC Diagnostic Program—High-Speed Loop Check

g) Teletype Input and Output Check

Computation and Data Flow Integrated Subsystem (CADFISS) Group: CADFISS testing, directed from the Goddard complex, consists of dynamically exercising all those units of the Mercury ground system which have an operational relationship to the computers. This relationship is defined as the avenues of direct data flow from each point of data initiation to points of intermediary and ultimate data use.

a) CADFISS Roll Call

The CADFISS roll call is performed to bring into the network all the sites that will be in operation for the mission. The roll call in effect sends a cue to each site, and the site upon reception of the cue transmits certain data to Goddard which is used for site radar calibration checks, data flow checks, error correction equipment checks, etc.

b) CADFISS Simulated Flight

The CADFISS simulated flight test is performed after the roll call. This test integrates the network in a simulated mission. The simulated mission is initiated at Cape Canaveral by first supplying data to the Mercury Program System of a simulated trajectory. The program system then takes the data supplied, projects an orbit, sends acquisition data to the sites and expects to receive from each of the radar sites, additional data to update and correct the orbit predictions.

4.1.1.2 Communications Group

The GSFC Mercury Communications Group, headed by the Communications Director, is responsible for establishing ground communications procedures; coordinating specialized network user procedural requirements, confirming the support capability of the communications network, establishing and putting into effect mission and/or associated test schedules and maintaining and improving network efficiency.

The Communications Liaison Coordinator is directly responsible for the supervision of the interface between computer and communications networks. He relays the orders and recommendations of the Communications Director to the Computer Operational Director and monitors the activities in the computer area to ensure that the orders are properly executed.

4.1.2 Goddard Countdown Procedures

Table 4–1 contains the MA–4 countdown procedures. The countdown is limited to specifically designated activities which much occur in a prescribed order both one day before launch and on the day of launch. The Goddard references in the countdown pertain to personnel in the Computer room only. The presentations are made in terms of time (T–0 is the time of launch in minutes, and is the standard upon which all other time references are based), action, and the person responsible for executing the action. A glossary of the terms used in the MA–4 countdown is located on page 4–14.

TABLE 4–1 GODDARD COUNTDOWN PROCEDURES

T-Time		Location		Action	Position Responsible
Begin (Min)	End (Min)	Site Code	Area		
480		GSC		Kingston engineers and customer engineers M/O at Goddard.	
480		GSC		Kingston engineers and customer engineers perform the following tests on both computers and associated equipment. a) Diagnostic routines on IBM 7090's. b) Closed loop high-speed data test with DCC–9A program. c) Test input clocks with DCC–9A program. d) Test DCC TTY channels with bypass MST–124 Test.	CADFISS test conductor
420	360	BDA		Customer engineers check Bermuda computer and Output Status Console.	
380		GSC		CADFISS support M/O at Goddard.	
370	340	GSC		Kingston engineers calibrate plotboards and load plotboard charts.	CADFISS test conductor
370		CNV	MCC	MCC M/O — except MSGCN.	
		CNV	B–GE	B–GE buffer M/O.	
		CNV	IP	IP 7090 buffer M/O.	
		CNV	AMR	Radar subcable M/O.	
		CNV	AMR	Radar transmitters 1.16, 3.16, and 5.16 M/O.	
370	340	CNV	AMR MCC IP	Radars 1.16, 3.16, and 5.16 transmitters transmit static patterns to MCC radar receiver and IP 7090 buffer for signal alignment. Adjust isolation amplifiers at IP 7090 complex.	AMR/IP buffer R–TTY
370	340	GSC		High-speed interface checks between GSC and CNV as follows:	CADFISS test conductor
			IP	a) IP 7090 buffer patterns to GSC—computer A.	
			B–GE	b) B–GE buffer patterns to GSC—computer B.	

TABLE 4–1 GODDARD COUNTDOWN PROCEDURES (Cont'd)

T-Time Begin (Min)	T-Time End (Min)	Location Site Code	Location Area	Action	Position Responsible
MCC				c) Capsule communicator's check to GSC—duplex. Using the program for Telemetry Test, Chap. 5, MS–124, Vol. 3, and with telemetry initially all zeros, take the following actions in order given at intervals of four to five seconds: 1) Set Capsule Communicator's Console overrides to NORMAL and Data Quality Monitor (DQM) switches to IP 7090 and Launch. 2) Capsule Communicator's Console LIFT OFF switch to EVENT. 3) Capsule Communicator's Console ETR switch to EVENT. 4) Set Capsule Communicator's Console ABORT INIT. switch to EVENT. 5) Set Capsule Communicator's Console CAPS switch to EVENT. 6) Set Capsule Communicator's Console DQM switch to B–GE. 7) Set Capsule Communicator's Console DQM switch to ABORT. 8) Set Capsule Communicator's Console DQM switch to IP 7090. 9) Set Capsule Communicator's Console CAPS switch to NORMAL. 10) Set Capsule Communicator's Console ABORT INIT. switch to NORMAL. 11) Set Capsule Communicator's Console ETR switch to NORMAL. 12) Set Capsule Communicator's Console LIFT OFF switch to NORMAL. 13) Use the sequencer to send these events to the Capsule Communicator's Console: LIFT OFF, ETR, ABORT INIT., CAPS. 14) Set Capsule Communicator's Console LIFT OFF switch to NO-EVENT. 15) Set Capsule Communicator's Console ETR switch to NO-EVENT. 16) Set Capsule Communicator's Console ABORT INIT. switch to NO-EVENT.	

TABLE 4–1 GODDARD COUNTDOWN PROCEDURES (Cont'd)

T-Time Begin (Min)	T-Time End (Min)	Location Site Code	Location Area	Action	Position Responsible
				17) Set Capsule Communicator's Console CAPS switch to NO-EVENT. 18) Set Capsule Communicator's Console CAPS switch to NORMAL. 19) Set Capsule Communicator's Console ABORT INIT. switch to NORMAL. 20) Set Capsule Communicator's Console ETR switch to NORMAL. 21) Set Capsule Communicator's Console LIFT OFF switch to NORMAL. 22) Set DQM switch to LAUNCH. 23) Terminate test. d) GSC high-speed transmitter patterns to MCC. GSC to use Kingston high-speed diagnostic program on items a) through c).	
370	340	CNV	MCC	Calibrate plotboards and load CADFISS plotboard charts.	Plotboard operators
360		BDA		All personnel on site check in on M&O loop.	
360	345	BDA		Load and cycle operational program for two WWV traps.	Computer operator
345		BDA		Teletype line test.	BDA GCC
345	330	BDA		Local T/E buffer and tape recorder checks.	Data computer operator
345		BDA		Begin display calibrations.	TM
345		BDA		Electrospan checks.	AA/TH
340	330	CNV	MCC IP B–GE	Perform final preparations for roll call test as follows: a) Set all equipment to operate condition and unseat digital junction plugboard. b) Set MES, CAPCOM, RETRO, and DQM switches for roll call test No. 26. c) Select high-speed data lines at receiving registers and select desired register.	Support/Data sel.
340	330	GSC		Load and cycle CADFISS roll call program–duplex.	CADFISS test conduction
335		CNV	ALL	Status reports to FIDO.	Area supervisors

TABLE 4–1 GODDARD COUNTDOWN PROCEDURES (Cont'd)

T-Time Begin (Min)	T-Time End (Min)	Location Site Code	Location Area	Action	Position Responsible
335		GSC		GSC status report to FIDO for relay to NSM.	CADFISS test conductor
331		GSC		Commence 60 second count for start of CADFISS roll call test with CNV.	CADFISS test conductor
331		CNV	MCC	Place digital junction plugboard in seated position.	Data sel.
330		CNV		CNV and GSC status report to NSM.	FIDO
330		BDA		Events recorder check.	Command TM
330	300	BDA		Radar slew Checks.	Verlort/FPS16/ Data/comp. op.
330	300	GSC		CADFISS roll call test with response from CNV only.	CADFISS test conductors
		CNV	MCC IP B–GE AMR	Test Nos. 26, 28, 42, 44. Duplex. a) Response to 26 from tapes at buffers. b) Response to 42 and 44 from tapes at radar sites. Response to 28 from T/E buffer switch box. c) Check output status console and ASR 140 and 141.	
310	300	GSC		GSC reports results of roll call test to FIDO.	CADFISS test conductor
310		BDA		T/E buffer check.	TM/Data
300	280	GSC		Roll call test summary report. Computer A.	CADFISS test conductor
300		BDA		Slaving checks.	G/A/TM/FPS16/ AA/ADC/TH/ Command/Verlort
300	270	BDA		FDO plotboard calibration.	Control room/ comp. op.
300	270	GSC CNV	ALL	Perform selected interface operations to isolate high-speed data link malfunctions if required. Computer B.	CADFISS test conductor
280	270	GSC		GSC reports results of test summary report to FIDO.	CADFISS test conductor

TABLE 4–I GODDARD COUNTDOWN PROCEDURES (Cont'd)

T-Time		Location		Action	Position Responsible
Begin (Min)	End (Min)	Site Code	Area		
280	270	GSC		Load AMR slew check program on computer A.	System test conductor
270	255	BDA		Teletype input-output checks.	BDA GCC/ comp. op.
270	250	GSC CNV	 IP	AMR radar slew check on computer A.	System test test conductor
270	240	ALL		Final preparations for roll call tests with all sites.	CADFISS test conductor
270	250	GSC		Prepare roll call tapes on computer B.	CADFISS test conductor
270	240	GSC		Patch the following teletype equipment as specified. a) ROTR 15 to circuit 7005–20. b) ROTR 17 to circuit USAF–02. c) ROTR 16 to circuit 7005–21. d) RO 147 to circuit 7005–10. e) RO 146 to circuit 7005–17. f) ASR 140 to circuit 7005–11. g) ASR 141 to circuit 7005–02.	Comm. coord.
270	250	CNV	MCC IP B–GE	Perform final preparations for roll call test as follows: a) Set all equipment to operate condition and unseat digital junction plugboard. b) Reload plotboards and place in operate position. c) Set MES, CAPCOM, RETRO, and DQM switches for roll call test No. 26. d) Select high-speed data lines at 408 bit receiving registers and select desired register for initial data.	Support/Data sel.
255	240	BDA		Prepare for CADFISS short roll call and load associated program.	Comp. op.
250	240	GSC		Load and cycle CADFISS roll call program. Duplex.	CADFISS test conductor
250		CNV	AMR	Radars 1.16, 3.16, and 5.16 M/O and locked on boresight towers.	AMR

TABLE 4–1 GODDARD COUNTDOWN PROCEDURES (Cont'd)

T-Time Begin (Min)	T-Time End (Min)	Location Site Code	Location Area	Action	Position Responsible
			IP B–GE	IP computer ready for roll call at T–240. B–GE computer ready for roll call at T–240 except F–O day.	IP B–GE
250		CNV GSC		Status reports to FIDO. GSC status report to FIDO for relay to NSM.	Area supervisors/CADFISS test conductor
245		CNV	MCC	CNV and GSC status reports to NSM.	FIDO
241		GSC		Commence 60 second count for start of CADFISS roll call test with all sites.	CADFISS test conductor/
		CNV	MCC	Place digital junction plugboard in seated position.	Data sel.
240		BDA		Participate in CADFISS short roll call.	BDA GCC/Verlort/FPS16/Data/Comp. op.
240	180	ALL		CADFISS roll call test with all sites. Duplex computers. Teletype message traffic restricted to CADFISS cues and responses or control message initiated by the NSM. Hold all other teletype traffic until BRF message releases network.	
225		GSC		Start real time CADFISS reports to NSM.	
210	180	GSC		GSC reports test progress report to NSM at MCC.	CADFISS test conductor
195	180	GSC		CADFISS roll call test summary. Computer B.	CADFISS test conductor
180		BDA		Plotboard calibration.	Verlort/FPS16/plotboard
180	165	BDA		Update station characteristics tape.	Comp. op.
180	175	GSC		Load duplex computers for trajectory run from B–GE and IP operational data recorders.	Comp. op.
175	160	GSC CNV	IP B–GE	Trajectory confidence check. Tape inputs from operational data recorders.	Systems test conductor
165	140	BDA		Computer time optional — Bermuda.	

TABLE 4–1 GODDARD COUNTDOWN PROCEDURES (Cont'd)

T-Time Begin (Min)	T-Time End (Min)	Location Site Code	Location Area	Action	Position Responsible
160	130			Tracking system option period for GSC and radar sites — Computer A. NOTE: MCC may request high-speed or low-speed re-runs for problems noted but not fixed prior to T–180 Min. TTY traffic not restricted except for sites required to rerun CSRC.	
160		GSC		Load computer B with slew program and stand by for AMR slew check at T–145 Min.	Systems test conductor
155		BDA		TM events panel check.	TM/flt. cont.
150	140	CNV	MCC B–GE	B–GE pad check. Data remoted to MCC only.	Data sel.
145	135	BDA		Discrete checks.	TM/Data/comp. op./flt. cont.
145	130	CNV GSC		AMR slew test. Computer B.	Systems test conductor
140		BDA		FIDO command checks.	Command/TM/ Flt. cont.
130	105	GSC		Perform radar data flow test. Cues 41 and 42 computer A and all radar sites except CNV. TTY message traffic restricted to CADFISS cues and responses or control messages initiated by the NSM. Hold all other TTY traffic until BRF message releases network. T–130 to T–105 Min. B computer at option of FIDO. If FIDO has no requirements the radar slew data may be dumped. If this is not required, run test patterns to GSC using Kingston high-speed diagnostic program.	NSM/CADFISS test director
105	90	BDA		Slew test.	Verlort/FPS16/ Data/comp. op.
105	100	GSC	CMPR	Load B/GE data link test program launch day only.	Comp. op.
100	85	GSC	CMPR	Receive and analyze B/GE data link test launch day only.	Comp. op.

TABLE 4–I GODDARD COUNTDOWN PROCEDURES (Cont'd)

T-Time		Location		Action	Position Responsible
Begin (Min)	End (Min)	Site Code	Area		
90	75	BDA	CMPR	Load operational program, enter GMT, and cycle program for two WWV traps.	Comp. op.
85	75	GSC	CMPR	Load operational program	Comp. op.
75	60	BDA		Local trajectory confidence check.	Comp. op./FIDO
75	55	GSC CNV	 IP	Trajectory run live from IP 7090 computer. Tape inputs from BDA and CYI.	
		BDA CYI	MCC		
55	30			GSC and radar sites. Tracking system option period. High-speed check or MCC may request a low-speed confidence check following extended hold periods. Sites should be prepared to re-run the CADFISS 40 series. No TTY restriction unless CSRC is re-run with remote sites.	
55	30	BDA		Computer time optional — Bermuda.	
45		BDA		Brief slaving check.	G/A TM/Command/Verlort/FPS16/AA/ADC/TH
30		BDA		Manual intercom, check in, in order.	
30		BDA		Start computer cycling.	Comp. op.
25	20	GSC CNV	CMPR B–GE	B–GE data link test. Launch day only.	Comp. op./ Burr. TC.
15		BDA		Notify C&W of critical period.	BDA GCC
15		BDA		Both radars locked on boresite.	
15		BDA		Film 10 Sec FPS16 nixie readout, turn bore — site transmitter off.	Data Monitor
12		BDA		Check radar dials for boresite coordinates.	
7		GSC	CMPR	Operational program is loaded into computer A and is cycling at T minus 7.	NASA REP Comp. op.
4		GSC	CMPR	Operational program is loaded into computer B and is cycling at T minus 4.	NASA REP Comp. op.
4		CNV	MCC	Sum message.	

TABLE 4–1 GODDARD COUNTDOWN PROCEDURES (Cont'd)

T-Time		Location		Action	Position Responsible
Begin (Min)	End (Min)	Site Code	Area		
00		BDA		Enter GMT.	Computer operator
		GSC	CMPR	Mission computations.	Computer operator
		GSC	CMPR	Mission computations.	Comp. one
		BDA	CMPR	Mission computations.	Comp. op.
				Post Flight Analysis.	
				Support terminated.	
				The following tests will be run on the day before launch.	
		CNV GSC		Trajectory runs live from IP and B/GE for FIDO. These will be conducted as specified by the Flight Dynamics Officer.	
				Test #1 — Burroughs data via GSFC 1. CAPCOM. — Give 20 Sec. count with liftoff on his mark. 2. FIDO — give 5 sec. count, switch to B computer at T equals one min. give 5 sec. count, return to computer A at T equals two min. 3. CAPCOM. — At T equal 2 min. 36 sec. use override to give tower rockets fired and tower separation. 4. FIDO — give 5 sec. count and switch to computer B at T equal one min. Give 5 sec. count, return to computer A at T equal 4 min. 5. CAPCOM. — at T equal 4 min. 57 sec. use override to give capsule separation.	
				Test #2 — Burroughs data direct. 1. CAPCOM. — give T/M events as in Test #1.	
				Test #3 — IP 7090 data. 1. Same as test #1 up to time of C. O.	

TABLE 4–1 GODDARD COUNTDOWN PROCEDURES (Cont'd)

T-Time Begin (Min)	T-Time End (Min)	Location Site Code	Location Area	Action	Position Responsible
				2. CAPCOM. — at T equal 4 min. 56 sec. Use override to give SECO — if not available use abort override. At T equal 4 min. 57 sec. use override to give capsule saparation.	
				Test #4 — Burroughs and IP 7090 data. 1. Data select — IP 7090. 2. CAPCOM. — same as test #1. 3. FIDO — Request switch to GE via GSFC at approximately T equal 40 sec.	
				Test #5 — IP 7090 data. 1. FIDO — test run with computer A. 2. CAPCOM. — give liftoff after 20 sec. count. Tower rockets fired and tower separation at normal time. At T equal 3 min. give abort override to event. Give SECO override and capsule sep. at normal time.	
				Test #6 — Burroughs data via GSFC. 1. Same as test #5 except that SECO override given at T equal 3 min. instead of abort override.	
				Test #7 — IP 7090 data. 1. FIDO — run with computer A. 2. CAPCOM. — give liftoff after 20 sec. count. At T equal 2 min. 36 sec. give tower sep. to no event. At T equal 4 min. 57 sec. give the following overrides: a) SECO to event. b) Tower rockets fired to event. c) Cap. sep. to event.	
				Test #8 — Burroughs data via GSFC. 1. FIDO — run with computer B. 2. Burroughs — At T equal 4 min. 46 sec. stop transmission of all data to GSFC. 3. CAPCOM. — at T equal 4 min. 57 sec. give cap. sep. override to event.	
				End of F minus 1 day support.	

GLOSSARY FOR THE MA-4 COUNTDOWN

AA/TH—Acquisition Aids/Town Hill

ALL—All sites

AMR—Atlantic Missile Test Range

ASR—Automatic Send/Receive

BDA—Bermuda

B-GE—Burroughs-General Electric

BRF—Briefing (message)

Burr TC—Burroughs Guidance Computer Operator

CAPS—Capsule Separation

CAPCOM—Capsule Communicator

CNV—Cape Canaveral

CMPR—Computer

CO—Computer Operations

CYI—Canary Island

DQM—Data Quality Monitor

ETR—Estimated Time of Recovery

FIDO—Flight Dynamics Officer

GA/TM—Ground-to-air/Telemetry

GCC—Goddard Communications Center

GMT—Greenwich Mean Time

GSFC—Goddard Space Flight Center

IP—Impact Predicator

MCC—Mercury Control Center

M/O—Maintenance and Operation

MES—Message

NASA REP—NASA Representative

NSM—Network Status Monitor

RO—Teletype Page Printer

ROTR—Teletype Printer and Retransmitter

SECO—Sustainer Engine Cutoff

T/E—Telemetry Event

TM—Telemetry

TTY—Teletype

4.2 BERMUDA COUNTDOWN

The Bermuda site's role in a Project Mercury mission is particularly critical during the launch phase. Functioning as a backup activity to the Mercury Control Center (MCC) at Cape Canaveral, the station monitors the launch and, in the event that MCC is unable to make the GO, NO-GO decision, determines whether to continue or abort the flight. Bermuda functions as a normal tracking station after the launch phase.

This section deals very briefly with the Bermuda personnel who man the station and its equipment during the launch period, and presents in short form a description of launch countdown procedures at Bermuda.

4.2.1 Mission Support Groups

Mission support groups may be divided into two categories—those associated with the computer and Mercury programming and those concerned with communications and control.

4.2.1.1 Programming and Related Groups

These groups operate, test or maintain the computer and computer-associated equipment. All personnel initiate or participate in preflight checks prior to the mission, and most are directly involved with computer operations during the mission. This category of persons is divided into: the Operational Programming Group, Special Service Engineer (Milco Maintenance Engineer), Customer Engineer (IBM 7090 and DCC Maintenance Engineer), and the Computation and Data Flow Integrated Subsystem (CADFISS) Group.

Operational Programming Group: This is one of the groups responsible for developing and testing the Mercury Program System. Operational Programming operates the system during premission, mission and postmission periods, and supports the countdown as follows (T–O is launch; all time is referenced to that event and is in hours and minutes):

Time	Procedure
T—6:00	Operational program loaded and cycled for two WWV traps.
T—3:15	Station Characteristics tape updated.
T—1:45	Operational program loaded and cycled.
T—1:15	Trajectory exercise simulated.
T—0:30	Operational program loaded and cycled.
T+0:30	Operational program reloaded and cycled for next pass.

Special Service Engineer—Milco Maintenance: The Special Service Engineer is responsible for maintaining the Milco equipment—Ampex tape recorder, data transmitter and data receiver. The following procedures are undertaken by the Special Service Engineer during countdown:

Time	Procedure
T—5:45	Telemetry event buffer and Ampex recorder checks
T—5:30	Slew checks
T—5:00	Plotboard calibration
T—4:30	Teletype input/output checks
T—4:15	CADFISS roll call
T—3:15	Status report
T—2:15	Discrete checks

Customer Engineer—IBM 709 computer and DCC maintenance: The Customer Engineer is responsible for maintaining the IBM 709 computer complex. Equipment for which he is responsible includes: IBM 709 computer, data communications channel, digital-to-analog converter, transfer register, and the output status console. From T—10:00 to T—6:00 the Customer Engineer must check out the entire 709 computer system; for the remainder of the countdown his responsibility is to be ready for any unexpected events.

Computation and Data Flow Integrated Subsystem (CADFISS) Group: The CADFISS group directs its testing procedures from the Goddard Computing and Communications Center. The operational readiness of the operating program and of all interconnected hardware related to the computers are checked by the CADFISS Test Director at Goddard and by his counterparts at the sites. Bermuda's responsibility in CADFISS testing is managed by the local Test Director and the Special Service Engineer. Tests are made from T—5:00 to T—3:15 and involve plotboard calibration, teletype input/output checks and radar checks. A status report is transmitted to Goddard upon checkout of the system.

4.2.1.2 Communications Groups

Groups participating in the countdown but not directly involved with the operational program are (1) the Communications Group, (2) the Maintenance and Operations (M & O) Group and (3) the Flight Dynamics Officer. Duties of the first two groups are interrelated during the entire mission; the latter's most important activities take place during launch and insertion. However, it is necessary that computer room personnel, communications and M & O personnel, and the Flight Dynamics Officer maintain communications during a Mercury flight (primarily from lift-off through insertion).

Communications Group: This group prepares ground communications for mission operation, aids in establishing and implementing mission and/or associated test schedules, and is responsible for verifying the applicable network test results to ascertain that circuits, equipment and operational procedures are functioning properly to provide adequate mission support. During operational periods the Communications Group ensures that mission traffic flow is handled efficiently and protected against interference in any form.

Maintenance and Operations (M & O) Group: The Maintenance and Operations Group is directly responsible to the Communications Director. M & O supports the Communications Group on all matters pertaining to the operation and control of communications, and participates in planning and implementing mission and nonmission testing.

Flight Dynamics Officer (FDO): As a backup to the Filght Dynamics Officer at the Mercury Control Center, the Bermuda Flight Dynamics Officer independently monitors launch trajectory and insertion parameters. If Cape Canaveral is unable for any reason to evaluate these parameters or if communications fail so the FDO at Bermuda is unaware of the decision made at the Mercury Control Center, he can assume control of and make the GO, NO-GO decision to continue or abort the flight.

4.2.2 Bermuda Countdown Procedures

Countdown procedures are time-oriented descriptions of the final checks necessary to determine station operational readiness for a mission; the responsibility for each action is also detailed. Countdown procedures are limited to specifically designated activities which must occur in the same order both one day prior to, and on, the date of launch.

The Bermuda countdown procedures presented in Table 4–2 relate only to the computer room and the operational program. The presentation is made in terms of time (T–O is the time of launch in hours and minutes, and is the standard upon which all other time references are based), procedure, and the person responsible for executing the action.

TABLE 4–2. BERMUDA COUNTDOWN PROCEDURES*

Begin	End	Interval (in hours)	Action	Person Responsible
T–10:00	T–6:00	4:00	IBM 709 computer and DCC checks; digital-to-analog converter, transfer register and Output Status Console Checks	Customer Engineer
T–6:00	T–5:45	0:15	Operational program loaded and cycled for two WWV traps	Operational Program Director
T–5:45	T–5:30	0:15	Telemetry event buffer and data recorder checks	Special Service Engineer
T–5:30	T–5:00	0:30	Radar slew checks	
T–5:00	T–4:30	0:30	Plotboard calibration	
T–4:30	T–4:15	0:15	Teletype input/output checks	
T–4:14	T–3:15	1:00	CADFISS roll call	
T–3:15			Status report	
T–3:15	T–3:00	0:15	Station Characteristics tape (U0STUP program) updated	Operational Program Director
T–3:00			Computer area cleared of personnel not concerned with mission computation or control	Special Service Engineer
T–2:25	T–2:15	0:10	Discrete data checks	
T–2:15	T–1:45	0:30	Radar slew checks	
T–1:45	T–1:15	0:30	Operational program loaded and cycled	Operational Program Director
T–1:15	T–1:00	0:15	Trajectory exercise simulated	
T–1:10			Status report	
T–0:30	T–0:00	0:30	Operational program loaded and cycled	
T–0:00			Lift-off	
T+0:30			Operational program reloaded and cycled for next pass	Operational Program Director

*(T–1 Day; to be repeated on the date of launch.)